Product manual

Articulated robot

IRB 4400/45
IRB 4400/60
IRB 4400/L30
IRB 4400/L10
IRB 4400 - S
IRB 4450S
M2004

Product manual

IRB 4400 - 45

IRB 4400 - 60

IRB 4400 - L10

IRB 4400 - L30

IRB 4400 - S

IRB 4450S

M2000

M2004

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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

A maintenance/repair/installation craftsman 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, service	Safety information
Installation and commissioning	Information about installation of the robot.
Maintenance	Information about maintenance work, including maintenance schedules.
Repair	Information about repair work.
Calibration information	Procedures that does not require specific calibration equipment. General information about calibration.
Decommissioning	Environmental information about the robot and its components.
Reference information	Useful information when performing installation, maintenance or repair work (lists of necessary tools, reference documents, safety standards.
Part list	Complete list of robot parts, shown in the exploded views or foldouts.

Continues on next page

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Continued

Chapter	Contents
Exploded views / Foldouts	Detailed illustrations of the robot with reference numbers to the part list.
Circuit diagram	Reference to the circuit diagram for the robot.

Revisions

Revision	Description
-	First edition. Replaces previous manuals: • Installation and Commissioning Manual • Maintenance Manual • Repair Manual, part 1 • Repair Manual, part 2. Changes made in the material from the previous manuals: • Model M2004 implemented.
A	Chapter *Safety, service* replaced with chapter *Safety*. Chapter *Calibration* replaced with chapter *Calibration information*. Removed chapter *Calibration, M2004*. Section *Document references* is completed with article numbers for calibration manuals.
B	Yaskawa motors been added.
C	Robot model IRB 4450S added.
D	Foundry Prime (Water jet application) added.
E	*Cleanroom* added. Changes made in: • Prerequisites in section Overview • Oil change in section Maintenance
F	Content updated in chapter/section: • Section *What is an emergency stop?* added to chapter *Safety*. • Maintenance/Maintenance schedule: Interval for replacement of battery pack changed • Maintenance/Cleaning of robot
G	Missing spare part in chapter Spare parts, section *Upper arm, axes 4-6*, added: • Item 29, Gear axis 6
H	This revision includes the following addtions and/or changes: • Inspection of surface treatment added to *Maintenance schedule on page 95* (Foundry Prime). • Circuit diagrams are not included in this document but delivered as separate files. See *Circuit diagram on page 291*. • List of standards updated, see *Applicable safety standards on page 266*. • Decommissioning chapter added. The chapter *Safety* updated with: • Updated safety signal graphics for the levels *Danger* and *Warning*, see *Safety signals in the manual on page 32*. • New safety labels on the manipulators, see *Safety symbols on the manipulator labels on page 34*. • Revised terminology: *robot* replaced with *manipulator*.

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Product documentation, M2000/M2000A

General

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

Product manuals

All hardware, manipulators and controllers will be delivered with a **Product manual** that contains:

- Safety information.
- Installation and commissioning (descriptions of mechanical installation, electrical connections).
- Maintenance (descriptions of all required preventive maintenance procedures including intervals).
- Repair (descriptions of all recommended repair procedures including spare parts).
- Additional procedures, if any (calibration, decommissioning).
- Reference information (article numbers for documentation referred to in Product manual, procedures, lists of tools, safety standards).
- Parts list.
- Foldouts or exploded views.
- Circuit diagrams (or references to circuit diagrams).

Software manuals

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

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

Controller hardware option manual

Each hardware option for the controller is supplied with its own documentation. Each document set contains the types of information specified below:

- Installation information
- Repair information
- Maintenance information

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

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Product documentation, M2004

Categories for manipulator documentation

The manipulator documentation 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 M2004 manipulator systems.

Product manuals

All hardware, manipulators and controllers will be delivered with a **Product manual** that contains:

- Safety information.
- Installation and commissioning (descriptions of mechanical installation, electrical connections).
- Maintenance (descriptions of all required preventive maintenance procedures including intervals).
- Repair (descriptions of all recommended repair procedures including spare parts).
- Additional procedures, if any (calibration, decommissioning).
- Reference information (article numbers for documentation referred to in Product manual, procedures, lists of tools, safety standards).
- Parts list.
- Foldouts or exploded views.
- Circuit diagrams (or references to circuit diagrams).

Technical reference manuals

The technical reference manuals describe the manipulator software in general and contain relevant reference information.

- **RAPID Overview**: An overview of the RAPID programming language.
- **RAPID Instructions, Functions and Data types**: Description and syntax for all RAPID instructions, functions, and data types.
- **RAPID Kernel**: A formal description of the RAPID programming language.
- **System parameters**: Description of system parameters and configuration workflows.

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, CD with PC software).
- How to use the application.
- Examples of how to use the application.

Continues on next page

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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:

- **Emergency safety information**
- **General safety information**
- **Getting started, IRC5 and RobotStudio**
- **IRC5 with FlexPendant**
- **RobotStudio**
- **Introduction to RAPID**
- **Trouble shooting**, for the controller and manipulator.

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How to read the product manual

Reading the procedures

The procedures contain references to figures, tools, material, etc. 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 13*.

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1 Safety

1.1. Introduction to safety information

Overview

The safety information in this manual is divided in two 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 14*.
- 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 32*.

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1.2 General safety information

1.2.1. Safety in the manipulator system

Validity and responsibility

The information does not cover how to design, install and operate a complete system, nor does it cover all peripheral equipment that can influence the safety of the total 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 manipulator is installed.

The users of ABB industrial manipulators 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 manipulator system are designed and installed correctly. Personnel working with manipulators must be familiar with the operation and handling of the industrial manipulator as described in the applicable documents, for example:

- *User's Guide - S4Cplus* (M2000)
- *Operating manual - IRC5 with FlexPendant*
- *Product manual*

Connection of external safety devices

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

Limitation of liability

Any information given in this manual regarding safety must not be construed as a warranty by ABB that the industrial manipulator 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 manipulator	Installation and commissioning
Changing operating modes	User´s Guide - S4Cplus (RobotWare 4.0) Operating manual - IRC5 with FlexPendant	Start-up Operating modes
Restricting the working space	Product manual for the manipulator	Installation and commissioning

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1.2.2. Safety risks

1.2.2.1. Safety risks during installation and service work on manipulators

Overview

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

General risks during installation and service

- The instructions in the Product manual in the chapter *Installation and commissioning* must always be followed.
- Emergency stop buttons must be positioned in easily accessible places so that the manipulator 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 the manipulator must have the appropriate training for the equipment in question and in any safety matters associated with it.

Nation/region specific regulations

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

Non-voltage related risks

- Safety zones, which must be crossed before admittance, must be set up in front of the manipulator'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 manipulator's working space.
- The axes are affected by the force of gravity when the brakes are released. In addition to the risk of being hit by moving manipulator parts, there is a risk of being crushed by the parallel arm (if there is one).
- Energy stored in the manipulator for the purpose of counterbalancing certain axes may be released if the manipulator, 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 manipulator as a ladder, that is, do not climb on the manipulator motors or other parts during service work. There is a serious risk of slipping because of the high temperature of the motors or oil spills that can occur on the manipulator.

To be observed by the supplier of the complete system

- 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.

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1.2.2.1. Safety risks during installation and service work on manipulators

Continued

Complete manipulator

Safety risk	Description
Hot components!	**CAUTION!** Motors and gears are HOT after running the manipulator! Touching motors and gears may result in burns! With a higher environment temperature, more surfaces on the manipulator will get HOT and may also result in burns.
Removed parts may result in collapse of manipulator!	**WARNING!** Take any necessary measures to ensure that the manipulator does not collapse as parts are removed, e.g. secure the lower arm with fixtures if removing motor, axis 2.

Cabling

Safety risk	Description
Cable packs are sensitive to mechanical damage!	**CAUTION!** The cable packs are sensitive to mechanical damage! They must be handled with care, especially the connectors, in order to avoid damaging them!

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!

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1.2.2.2. CAUTION - Hot parts may cause burns!

Description

During normal operation, many manipulator parts become hot, especially the drive motors and gears. 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 manipulator get hot and may result in burns.

Elimination

The instructions below detail how to avoid the dangers specified above:

	Action	Info
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.	

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1.2.2.3. Safety risks related to tools/workpieces

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 workpieces in the event of a power failure or a disturbance to the controller.

CAUTION!

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

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1.2.2.4. Safety risks related to pneumatic/hydraulic systems

General

Special safety regulations apply to pneumatic and hydraulic systems.

Residual energy

- Residual energy can be present in these systems. After shutdown, particular care must be taken.
- The pressure in pneumatic and hydraulic systems must be released before starting to repair them.

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.

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1.2.2.5. Safety risks during operational disturbances

General

- The industrial manipulator 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.

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1.2.2.6. Risks associated with live electric parts

Voltage related risks, general

- 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 mains switch to OFF) when repairing faults, disconnecting electric leads and disconnecting or connecting units.
- The mains supply to the robot must be connected in such a way that it can be turned off from outside the robot's working space.

Voltage related risks, controller S4Cplus

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

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

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Continues on next page

1.2.2.6. Risks associated with live electric parts

Continued

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 mains supply/mains switch
- The transformers
- The power unit
- The control power supply (230 VAC)
- The rectifier unit (400-480 VAC and 700 VDC. Note: Capacitors!)
- The drive unit (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 power supply unit for additional tools.
- The external voltage connected to the controller remains live even when the robot is disconnected from the mains.
- Additional connections.

Voltage related risks, manipulator

A danger of high voltage is associated with the manipulator 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, see the chapter *Installation and commissioning* in the Product manual).

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.

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1.2.3. Safety actions

1.2.3.1. Safety fence dimensions

General

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

Dimensioning

Dimension the fence or enclosure to enable it to withstand the force created if the load being handled by the manipulator is dropped or released at maximum speed. Determine the maximum speed from the maximum velocities of the manipulator axes and from the position at which the manipulator 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 manipulator.

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1.2.3.2. Fire extinguishing

NOTE!

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

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1.2.3.3. Emergency release of the manipulator’s arm

Description

In an emergency situation, any of the manipulator's axes may be released manually by pushing the brake release buttons on the manipulator.

How to release the brakes is detailed in the section:

- *Manually releasing the brakes on page 63*.

The manipulator arm may be moved manually on smaller manipulator 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!

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1.2.3.4. Brake testing

When to test

During operation the holding brake of each axis motor is normally worn 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 checked as detailed below:

1. Run each manipulator axis to a position where the combined weight of the manipulator arm and any load is maximized (max. static load).
2. Switch the motor to the MOTORS OFF position with the Operating mode selector on the controller.
3. Check that the axis maintains its position.

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

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1.2.3.5. 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".

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1.2.3.6. Safe use of the FlexPendant

NOTE!

The enabling device is a push-button located on the side of the FlexPendant which, when pressed halfway in, takes the system to MOTORS ON. When the enabling device is released or pushed all the way in, the manipulator is taken to the MOTORS OFF state.

To ensure safe use of the FlexPendant, 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 manipulator to move.
- The programmer must always bring the FlexPendant with him/her when entering the manipulator's working space. This is to prevent anyone else taking control of the manipulator without the programmer’s knowledge.

Enabling device

The 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 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, manipulator operation is impossible.

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 is described in *Operating manual - IRC5 with FlexPendant*.

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1.2.3.7. Work inside the manipulator's working range

WARNING!

If work must be carried out within the manipulator’s work envelope, the following points must be observed:

- The operating mode selector on the controller must be in the manual mode position to render the enabling device operational and to block operation from a computer link or remote control panel.
- The manipulator’s speed is limited to max. 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.
- Pay attention to the rotating axes of the manipulator! Keep a distance to the axes in order not to 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 manipulator or inside the cell.
- Test the motor brake on each axis, according to the section *Brake testing on page 26*.

WARNING!

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

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1.2.4. Safety stops

1.2.4.1. What is an emergency stop?

Definition of emergency stop

An emergency stop is a state that overrides any other manipulator control, disconnects drive power from the manipulator motors, stops all moving parts and disconnects power from any potentially dangerous functions controlled by the manipulator system.

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

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

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

The default setting is uncontrolled stop. However, controlled stops are preferred since they minimize extra, unnecessary wear on the manipulator and the actions needed to return the manipulator system back to production. Please consult your plant or cell documentation to see how your manipulator 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 manipulator. For how to perform normal program stops, see the section *Stopping programs* in*Operating manual - IRC5 with FlexPendant*.

Classification of stops

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

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

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Continues on next page

Emergency stop devices

In a manipulator system there are several emergency stop devices 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 (on the Control Module on a Dual Cabinet Controller). There can also be other types of emergency stops on your manipulator. Consult your plant or cell documentation to see how your manipulator system is configured.

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1.3 Safety related instructions

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 this manual. 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.
- An instruction on how to eliminate the 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
danger	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, etc.
warning	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.
Electrical shock	ELECTRICAL SHOCK	Warns for electrical hazards which could result in severe personal injury or death.
caution	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.

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Continued

Symbol	Designation	Significance
Electrostatic discharge (ESD)	ELECTROSTATIC DISCHARGE (ESD)	Warns for electrostatic hazards which could result in severe damage to the product.
Note	NOTE	Describes important facts and conditions.
Tip	TIP	Describes where to find additional information or how to do an operation in an easier way.

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1.3.2. Safety symbols on the manipulator labels

Introduction to labels

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

Symbol 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.

Types of labels

Both the manipulator 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 manipulator 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 34*.

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

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.
xx0900000839	**Prohibition** Used in combinations with other symbols.

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Continued

Symbol	Description
xx0900000813	**Product manual** Read the product manual for details.
xx0900000816	**Before dismantling see product manual**
xx0900000815	**Do not dismantle** Dismantling 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 manipulator arm can fall down.
xx0900000810	**Tip risk when loosening bolts** The manipulator can tip over if the bolts are not securely fastened.
xx0900000817	**Crush** Risk for crush injuries.

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1.3.2. Safety symbols on the manipulator labels

Continued

Symbol	Description
xx0900000818	**Heat** Risk of heat that can cause burns.
xx0900000819	**Moving robot** The robot can move unexpectedly.
xx0900000820	**Brake release buttons**
xx0900000821	**Lifting bolt**
xx0900000822	**Lifting of robot**
xx0900000823	**Oil** Can be used in combination with prohibition if oil is not allowed.

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Continued

Symbol	Description
xx0900000824	**Mechanical stop**
xx0900000825	**Stored energy** Warns that this part contains stored energy. Used in combination with *Do not dismantle* symbol.
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.

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1.3.3. DANGER - Moving manipulators are potentially lethal!

Description

Any moving manipulator is a potentially lethal machine.

When running, the manipulator 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 manipulator.

Elimination

	Action	Note
1.	Before attempting to run the manipulator, 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*. How to use the hold-to-run control in RobotWare 4.0 is detailed in section *The Teach Pendant unit* in the *User Guide.*
3.	Make sure no personnel are present within the working range of the manipullator before pressing the start button.	

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1.3.4. 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.	Install all safety equipment properly!
3.	Make sure all personnel are standing at a safe distance from the robot, that is out of its reach behind safety fences, etc!
4.	Pay special attention to the function of the part previously serviced!

Collision risks

CAUTION!

When programming the movements of the manipulator always check potential collision risks before the first test run!

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1.3.5. 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

The wrist strap button is located in the top right corner.

xx0500002171

A	Wrist strap button

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Continues on next page

Panel Mounted Controller

xx0600003249

A	Panel Mounted Control Module
B	Panel Mounted Drive Module
C	Wrist strap button NOTE! When not used, the wrist strap must always be attached to the wrist strap button.

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1.3.6. WARNING - Safety risks during work with gearbox lubricants (oil or grease)

Description

When handling the 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!

Warnings and elimination

Warning	Description	Elimination/Action
- **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.
. **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.
- **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.
- **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, check the correct level.
- **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!
- **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.

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1.3.6. WARNING - Safety risks during work with gearbox lubricants (oil or grease)

Continued

Warning	Description	Elimination/Action
- **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 refilling, check the lubricant level.

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1.3.6. WARNING - Safety risks during work with gearbox lubricants (oil or grease)

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2 Installation and commissioning

2.1. Introduction

General

This chapter contains information for installing the robot at the working site.

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

- load diagram
- permitted extra loads (equipment)
- location of extra loads (equipment).

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 13* before performing any installation work.

NOTE!

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

For more information see:

- Product manual - IRC5
- Product manual - IRC5 Compact
- Product manual - Panel Mounted Controller

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2.2 Unpacking

2.2.1. Pre-installation procedure

General

These instructions are to be used when unpacking and installing the robot for the first time. They also contain information useful later during re-installation of the robot.

Checking the pre-requisites for installation

The check-list below details what must be observed before proceeding with the actual installation of the robot:

1. Make sure only qualified installation personnel conforming to all national and local codes are allowed to perform the installation.
2. Make sure the robot is not damaged, by visually inspecting the robot and control cabinet exterior.
3. Make sure the lifting device to be used is dimensioned to handle the weight of the robot as specified in *Weight, robot on page 46*.
4. If the robot is not to be installed directly, it must be stored as described in *Storage conditions, robot on page 49*.
5. Make sure the expected operating environment of the robot conforms to the specifications as described in *Operating conditions, robot on page 49*.
6. Before taking the robot to the installation site, make sure the site conforms to *Loads on foundation, robot - all versions except IRB 4400/S and 4450S on page 47* and *Protection classes on page 49*.
7. When the robot is not fastened to the floor and standing still, the robot is not stable in the work area. Care must be taken when the arms are moved, so that the center of gravity is not displaced which may cause the robot to tip over.
8. When these prerequisites are met, the robot may be taken to its installation site as described in section *On-site installation on page 57*.

Weight, robot

The table below shows the weights of the different models:

Robot model	Weight
IRB 4400/45	985 kg
IRB 4400/60	1040 kg
IRB 4400/L10	1040 kg
IRB 4400/L30	1060 kg
IRB 4400/S	1290 kg
IRB 4450S	1080 kg

L - Long arm

S - Shelf mounted robot

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Loads on foundation, robot - all versions except IRB 4400/S and 4450S

The table below shows the various forces and torques working on the robot during different kinds of operation. Stress forces for the robot versions IRB 4400/S and IRB 4450S are detailed separately in the following tables.

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!

The rigidity of the foundation must be designed to minimize the affects of dynamic behaviour on the robot. For optimal performance, the frequency for the foundation bearing the robot must be higher than 30 Hz.

TuneServo can be used to adapt robot tuning for a non-optimal foundation.

Fxy and Mxy are vectors that can have any direction on the xy plane.

The illustration below shows the directions of the stress forces.

xx0300000254

Force	Endurance load (in operation)	Max. load (emergency stop)
Force xy	± 7500 N	± 9000 N
Force z	+9500 ± 2000 N	+9500 ± 3000 N
Torque xy	± 14000 Nm	± 16000 Nm
Torque z	± 2000 Nm	± 4000 Nm

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Continued

Loads on foundation, robot version IRB 4450S

The illustration below shows the directions of the stress forces.

xx0500002108

This table shows stress forces for the robot version IRB 4450S.

Force	Endurance load (in operation)	Max. load (emergency load)
Force xy	±7500 N	±10000 N
Force z	+9500 ±2000 N	+9500 ±4000 N
Torque xy	±14000 Nm	±16000 Nm
Torque z	±2000 Nm	±4000 Nm

Loads on foundation, robot version IRB 4400/S

xx0300000255

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This table shows stress forces for the robot version IRB 4400/S.

Force	Endurance load (in operation)	Max. load (emergency stop)
Force x	± 5000 N	± 7000 N
Force y	± 6000	± 9000 N
Force z	10 000 ± 5000 N	10 000 ± 7000 N
Torque x	± 8500 Nm	± 11 500 Nm
Torque y	3500 ± 14 000 Nm	3500 ± 11 500 Nm
Torque z	± 6500 Nm	± 11 000 Nm
Force x'	5000 ± 5000 N	5000 ± 7000 N
Force y'	± 6000 N	± 9000 N
Force z'	8500 ± 3000N	8500 ± 5500 N
Torque x'	± 9500 Nm	± 12 000 Nm
Torque y'	3500 ± 7500 Nm	3500 ± 11 500 Nm
Torque z'	± 2000 Nm	± 5500 Nm

Storage conditions, robot

The table below shows the allowed storage conditions for the robot:

Parameter	Value
Min. ambient temperature	-25° C
Max. ambient temperature	+55° C
Max. ambient temperature (less than 24 hrs)	+70° C
Max. ambient humidity	95% at constant temperature

Operating conditions, robot

The table below shows the allowed operating conditions for the robot:

Parameter	Value
Min. ambient temperature	+5° C
Max. ambient temperature	+45° C
Max. ambient humidity	95% at constant temperature

Protection classes

The table below shows the protection class of the robot:

Robot	Protection class
Standard version	IP54
Foundry version	IP67, steam washable

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2.2.2. Working range, IRB 4400/45 and /60

Extreme positions

The illustration below shows the extreme positions of the robot arms IRB 4400/45 and /60:

xx0300000241

Pos no.	Position X (mm)	Position Z (mm)	Angle Axis 2 (degrees)	Angle Axis 3 (degrees)
0	1080	1720	0	0
1	887	2140	0	-30
2	708	836	0	65
3	1894	221	95	-60
4	570	-126	95	40
5	51	1554	-70	40
6	227	1210	-70	65

Robot motion

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

Location of motion	Type of motion	Range of movement
Axis 1	Rotation motion	+165° to -165°
Axis 2	Arm motion	+95° to -70°
Axis 3	Arm motion	+65° to -60°
Axis 4	Wrist motion	+200° to -200°
Axis 5	Bend motion	+120° to -120°
Axis 6	Turn motion	+400° to -400°

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2.2.3. Working range, IRB 4400/L30

Extreme positions

The illustration below shows the extreme positions of the robot arm IRB 4400/L30:

xx0300000242

Positions in illustration	Position X (mm)	Position Z (mm)	Angle Axis 2 (degrees)	Angle Axis 3 (degrees)
B	1580	1720	0	0
C	1320	2390	0	-30
D	919	383	0	65
E	2303	-66	95	-60
F	180	-448	95	42
G	484	1804	-70	40
H	725	1254	-70	65

Robot motion

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

Location of motion	Type of motion	Range of movement
Axis 1	Rotation motion	+165° to -165°
Axis 2	Arm motion	+95° to -70°
Axis 3	Arm motion	+65° to -60°
Axis 4	Wrist motion	+200° to -200°
Axis 5	Bend motion	+120° to -120°
Axis 6	Turn motion	+400° to -400°

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2.2.4. Working range, IRB 4400/L10

Extreme positions

The illustration below shows the extreme positions of the robot arm IRB 4400/L10:

xx0300000244

Position in illustration	Position X (mm)	Position Z (mm)	Angle Axis 2 (degrees)	Angle Axis 3 (degrees)
B	1700	1720	0	0
C	1424	2450	0	-30
D	970	274	0	65
E	2401	-135	95	-60
F	500	-786	95	23.6
G	588	1864	-70	40
H	845	1265	-70	65

Robot motion

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

Location of motion	Type of motion	Range of movement
Axis 1	Rotation motion	+165° to -165°
Axis 2	Arm motion	+95° to -70°
Axis 3	Arm motion	+65° to -60°
Axis 4	Wrist motion	+200° to -200°
Axis 5	Bend motion	+120° to -120°
Axis 6	Turn motion	+400° to -400°

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2.2.5. Working range, IRB 4400/S

Extreme positions

The illustration below shows the extreme positions of the robot arm IRB 4400/S:

xx0300000243

Positions in illustration	Position X (mm)	Position Z (mm)	Angle Axis 2 (degrees)	Angle Axis 3 (degrees)
B	1580	1720	0	0
C	1320	2390	0	-30
D	919	383	0	65
E	2360	120	90	-60
F	239	-417	90	44
G	484	1804	-70	40
H	725	1254	-70	65

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Continued

Robot motion

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

Location of motion	Type of motion	Range of movement
Axis 1	Rotation motion	+135° to -135°
Axis 2	Arm motion	+90° to -70°
Axis 3	Arm motion	+65° to -60°
Axis 4	Wrist motion	+200° to -200°
Axis 5	Bend motion	+120° to -120°
Axis 6	Turn motion	+400° to -400°

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2.2.6. Working range, IRB 4450S

Extreme positions

The illustration below shows the extreme positions of the robot arm IRB 4450S:

xx0500002034

Positions in illustration	Position X (mm)	Position Z (mm)	Angle Axis 2 (degrees)	Angle Axis 3 (degrees)
B	2006	556	0	0
C	2190	978	0	-30
D	1101	239	0	65
E	1437	-1054	95	-60
F	294	-303	95	40
G	1195	1208	-70	40
H	1058	847	-70	65

Robot motion

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

Location of motion	Type of motion	Range of motion
Axis 1	Rotation motion	+135° to -135°
Axis 2	Arm motion	+90° to -70°
Axis 3	Arm motion	+65° to -60°
Axis 4	Wrist motion	+200° to -200°
Axis 5	Bend motion	+120° to -120°
Axis 6	Turn motion	+400° to -400°

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2.2.7. Risk of tipping/stability - IRB 4450S

Risk of tipping

When the robot model IRB 4450S not is 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.

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

Stability

The figure below shows the robot in its shipping position, which also is the most stable position.

xx0500002035

A	Angle (degress specified for the different versions in the lifting instruction)
B	Mechanical stop

WARNING!

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

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2.3 On-site installation

2.3.1. Lifting robot with round slings

General

Lift the robot using lifting straps and a traverse crane according to this section.

The instructions are separated for the robot versions IRB 4400/45, /60, /L10, /L30 and for robot versions IRB 4400/S and 4450S.

Required equipment

Equipment	Art. no.	Note
Crane		Lifting capacity: 2100kg (max. load at 90°)
Round slings, 2 m		Lifting capacity/sling: 1100kg 2 pcs for version IRB 4400/45, /60, /L10 and /L30 3 pcs for version IRB 4400/S if the erection position is to be 30° 3 pcs for version IRB 4450S
Lifting lugs		Type: OBK 7-8

WARNING!

The manipulator weighs 1300 kg! All lifting equipment used must be dimensioned accordingly!

WARNING!

Personnel must not, under any circumstances, be present under the suspended load!

CAUTION!

Failure to attach the straps correctly can cause the suspended load to tilt suddenly and cause both personal injury and severe damage to the load.

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Lifting, robot version IRB 4400/45, /60, /L10, /L30

The lifting equipment is attached to the robot as shown in the figure below.

xx0300000245

A	Angle (degrees specified for the different versions in the lifting instruction)
B	Lifting lug

Lifting instruction, IRB 4400/45, /60, /L10, /L30

The procedure below details how to lift the complete robot (IRB 4400/45, /60, /L10, /L30).

	Action	Info
1.	Release the brakes manually, to make it possible to alter the positions of the arms.	Detailed in section *Manually releasing the brakes on page 63*.
2.	Move the robot to the calibration position.	
3.	Move the lower arm backwards to get balance, according to angle specified to the right.	Angle (A) is shown in the figure *Lifting, robot version IRB 4400/45, /60, /L10, /L30 on page 58*. • IRB 4400/45 and /L30: A: -5° • IRB 4400/60 and /L10: A: 0°

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Continued

	Action	Info
4.	Attach the *round slings* to the special eye bolts on the gearbox unit for axes 2 and 3 using *lifting lugs*.	Shown in the figure *Lifting, robot version IRB 4400/45, /60, /L10, /L30 on page 58*. The roundsling and lifting lug dimensions must comply with the applicable standards specified in *Required equipment on page 57*.
5.	Lift the robot to its installation site. Make sure the slings do not rub against any sharp edges!	

Lifting robot version IRB 4400/S

The lifting equipment is attached to the robot as shown in the figure below.

xx0300000247

(1)	Lifting angle for the robot: 0°
(2)	Lifting angle for the robot: 30°
A	Angle (degrees specified for the different versions in the lifting instruction)
B	Axis 2
C	Lifting lug

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Continued

Lifting instruction, IRB 4400/S

The procedure below details how to lift the complete robot (IRB 4400/S).

	Action	Note
1.	Release the brakes manually, to make it possible to alter the positions of the arms.	Detailed in section *Manually releasing the brakes on page 63*.
2.	Move the robot to the calibration position.	
3.	Move the lower arm forward to get balance, according to angle specified to the right.	Angle (A) is shown in the figure *Lifting robot version IRB 4400/S on page 59*. If the robot liftangle is: • 0°, then A=25° • 30°, then A=0°
4.	Attach the *round slings* to the special eye bolts on the gearbox unit for axes 2 and 3 using *lifting lugs.* If the lifting angle of the robot is more than 0°, a round sling must also be attached to the rear of the robot.	Attachment points are shown in the figure *Lifting robot version IRB 4400/S on page 59*. The roundsling and lifting lug dimensions must comply with the applicable standards specified in *Required equipment on page 57*.
5.	Lift the robot to its installation site. Make sure the slings do not rub against any sharp edges!	

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Lifting robot version IRB 4450S

The lifting equipment is attached to the robot as shown in the figure below.

xx0500002035

A	Angle (degrees specified for the different versions in the lifting instruction)
B	Mechanical stop

Lifting instruction, IRB4450S

The procedure below details how to lift the complete robot (IRB 4450S)

	Action	Info
1.	Release the brakes manually, to make it possible to alter the positions of the arms.	Detailed in section *Manually releasing the brakes on page 63*.
2.	Move the robot to its shipping position.	See figure *Lifting robot version IRB 4450S on page 61*
3.	Move the robot to the calibration position.	
4.	Move the lower arm forward to get balance, according to angle specified to the right.	Angle (A) is shown in figure xx0500002035 above. If the robot liftangle is: 0° then A=-20°
5.	Attach the *round slings* to the special eye bolts on the gearbox unit for axes 2 and 3 using *lifting lugs.* Also attach the round slings around the mechanical stop as a third lifting point.	Attachment points are shown in figure xx0500002035 above. The roundsling and lifting lug dimensions must comply with the applicable standards specified in

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Continued

	Action	Info
6.	Lift the robot to its installation site. Make sure the slings do not rub against any sharp edges!	
7.	**Danger!** When the robot is put down, before attachment to the floor is done, the risk of tipping is big.	

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2.3.2. Manually releasing the brakes

General

The section below details how to release the holding brakes of each axis' motor.

This can be done in one of three ways:

- using the push-button when the robot is connected to the controller.
- using the push-button on the robot with an external power supply.
- using an external voltage supply directly on the respective brake.

DANGER!

When releasing the holding brakes with push-buttons, the robot must be properly attached!

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!

Using the push-button when the robot is connected to the controller

The procedure details how to release the holding brakes with push-buttons, when the robot is connected to the controller.

	Action	Note
1.	The internal brake release unit is located at the base of the robot.	 xx0300000198

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Continued

	Action	Note
2.	The brake release unit is equipped with six buttons for controlling the axes brakes. The buttons are numbered according to the numbers of the axes.	
3.	Release the holding brake on a particular axis by pressing the corresponding button on the push-button unit and keeping it depressed.	
4.	The brake will function again as soon as the button is released.	

Using the push-button on the robot with an external power supply

The procedure below details how to release the holding brakes with the push-buttons, when the robot is **not** connected to the controller.

	Action	Note
1.	Connect an external 24VDC power supply to the connector R1.MP on the robot base, as shown in the figure to the right. **Note!** Be careful not to interchange the 24V and 0V pins. If they are mixed up, damage can be caused to the brake release unit and the system board. Danger! DANGER! **Incorrect connections can cause all brakes to be released simultaneously!**	 xx0300000200 Connect to connector R1.MP: • 0V: pin B14 or B15 • +24V: pin B16

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Continued

	Action	Note
2.	Release the holding brake on a particular axis by pressing the corresponding button on the push-button unit and keeping it depressed.	The brake release unit is equipped with six buttons for controlling the axes brakes. The buttons are numbered according to the numbers of the axes. See the previous figure.
3.	The brake will function again as soon as the button is released.	

Using an external voltage supply directly on the respective brake

The procedure below details how to release the holding brake of a specific axis by supplying external voltage directly on the brake.

	Action	Note
1.	Every axis has a holding brake built into the axis motor. This holding brake may be released by connecting 24VDC power supply directly to one of the connectors in the motor. Danger! DANGER! **When power is connected directly to the brake cable, the brake will be released immediately when the power is switched on.** **This may cause some unexpected robot movements!**	Make the connection to the current motor according to the Circuit Diagram. See the chapter *Circuit diagram*.

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2.3.3. Orienting and securing the robot

General

This section details how to orient and secure the robot to the base plate after fitting it to the foundation.

Securing parts/facts

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

Securing parts/fact	Dimension/art. no.	Amount/Note
Securing screws, oiled	M20	3 pcs
Washers	Thickness: 3 mm Outer diameter: 36 mm Inner diameter: 21 mm	3 pcs
Guide sleeves	2151 0024-169	2 pcs Added to the rear bolt holes, to allow the same robot to be re-mounted without program adjustments.
Tightening torque	350 - 400 Nm	Oiled screws
Level surface requirements	 xx0300000251	

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Hole configuration and dimensions

The illustration below shows the hole configuration and hole dimensions of the robot base, seen from below.

The cut x-x shows the dimension of the rear bolt holes, where the guide sleeves may be used.

xx0300000252

A	Rear bolt holes
B	Center line, axis 1

Orienting and securing the robot

The procedure below details how to orient and secure the robot to the base plate after fitting the plate to the foundation.

WARNING!

The manipulator weighs 1300 kg! All lifting equipment used must be dimensioned accordingly!

Step	Action	Info/Illustration
1.	**Warning!** When the robot is put down, before attachment to the floor is done, the risk of tipping is big, if not properly secured.	
2.	Lift the robot.	Detailed in section *Lifting robot with round slings on page 57*.
3.	Move the robot to the vicinity of the installation site.	
4.	Fit two *guide sleeves* to the *rear bolt holes* in the base.	Art. no. is specified in *Securing parts/facts on page 66*. Shown in the figure *Hole configuration and dimensions on page 67*.
5.	Guide the robot gently using M20 screws while lowering it into its mounting position.	

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Continued

Step	Action	Info/Illustration
6.	Fit the *securing screws and washers* in the base attachment holes.	Specified in *Securing parts/ facts on page 66*. Attachment holes shown in the figure *Hole configuration and dimensions on page 67*.
7.	When bolting a mounting plate or frame to a concrete floor, follow the general instructions for expansion-shell bolts. The screw joint must be able to withstand the stress loads defined in section *Loads on foundation, robot - all versions except IRB 4400/S and 4450S on page 47*.	

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2.3.4. 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.

Never drill a hole in the robot without first consulting ABB!

Fitting equipment on upper arm, IRB 4400/45, /60, /L30, /S and IRB 4450S

The illustration below shows the mounting holes available for fitting extra equipment on the upper arm for robot versions IRB 4400/45, /60, /L30, /S and IRB 4450S.

The shaded area indicates the permitted positions (center of gravity) for any extra equipment mounted in the holes.

xx0300000264

E	Max. 15 kg
F	M8 (2x), holes used if option 043 is chosen. Depth of thread: 9 mm
G	M8 (3x) Depth of thread: 14 mm
H	571 mm for IRB 4400/45 and /60. 1071 mm for IRB 4400/S and /L30
I	Max. 5 kg for IRB 4400/45 and /60 at max. handling weight and max. 5 kg for IRB 4400/L30 and IRB 4450S at 25 kg handling weight
J	5 kg for IRB 4400/S and /L30 if the handling weight is max. 25 kg. If the handling weight is 30 kg: 0 kg allowed!
K	M6 (2x), tapped depth 12 mm

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Fitting equipment on upper arm, IRB 4400/L10

The illustration below shows the mounting holes available for fitting extra equipment on the upper arm for robot versions IRB 4400/L10.

The shaded area indicates the permitted positions (center of gravity) for any extra equipment mounted in the holes.

xx0300000265

C	Max. 15 kg
D	M6 (2x) Depth of thread: 9 mm
E	M8 (3x) Depth of thread: 14 mm
F	Max. 2 kg
G	M5 (2x)

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Fitting equipment on gearbox unit, IRB 4400/45, /60, /L10, /L30 and IRB 4400/S

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

The shaded area indicates the permitted positions (center of gravity) for any extra equipment mounted in the holes.

xx0300000266

A	M8 (3x), R=2. Depth 16 mm (if option 623 is chosen, these holes are occupied)
B	Max. 35 kg for IRB 4400/45, /60, /L10, /L30 (0 kg for IRB 4400/S)

Fitting equipment on gearbox unit, IRB 4450S

The illustration below shows the mounting holes available for fitting extra equipment on the gearbox unit

The shaded area indicates the permitted positions (center of gravity) for any extra equipment mounted in the holes.

xx0500002136

A	M8 (3x), R=2. Depth 16 mm (if option 623 is chosen, these holes are occupied)
B	Max. 35 kg for IRB 4450S

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Continued

Fitting equipment on mounting flange, IRB 4400/45, /60, /L30, /S and IRB 4450S

The illustration below shows the mechanical interface for the mounting flange, robot version IRB 4400/45, /60, /L30, /S and IRB 4450S.

Fitting equipment on mounting flange, IRB 4400/10

The illustration below shows the mechanical interface for the mounting flange, robot version IRB 4400/L10.

C	The hole can go through

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2.3.5. Loads

General

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

CAUTION!

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

References

Load diagrams, permitted extra loads (equipment) and their positions are specified in the *Product Specification*. The loads must also be defined in the software as detailed in *User's Guide*(RobotWare 4.0)*Operating manual IRC5 with FlexPendant*.

Stop time and braking distances

Robot motor brake performance depends on any loads attached. For information about brake performance, see *Product Specification* for the robot.

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2.4 Restricting the working range

2.4.1. Introduction

General

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

The working range of the following axes may be restricted:

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

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

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

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2.4.2. Mechanically restricting the working range of axis 1

Mechanically restricting the working range

The working range of axis 1 can be restricted mechanically by fitting additional mechanical stops to the base, as detailed in this section.

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Mechanical stop, axis 1	3HAB3833-1		Includes 2 additional stop lugs, 8 attachment screws, 8 plain washers and a label
Attachment screw	9ADA183-71		4 pcs/lug, included in 3HAB3833-1 M12x60
Washer	9ADA312-9		4 pcs/lug, included in 3HAB3833-1 13x24x2.5
Standard toolkit		3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Additional stops

The additional stops are fitted as shown in the figure.

xx0300000258

B	Mechanical stop lugs
C	Attachment screw and washer
D	Stop pin
E	Max. working range with stop lugs (250°)
F	Min. working range with stop lugs (127°)

Fitting, mechancial stop axis 1

How to fit the additional mechanical stop to the base is described in the procedure.

Mounting instructions are also supplied with the kit.

	Action	Note
1.	Determine the position of the stop lugsand mark the hole positions on the base.	See the figure *Additional stops on page 76* for guidance.
2.	Drill Ø10.2 mm to a maximum depth of 45 mm and tap with M12 thread. Min. thread depth 35 mm.	
3.	Fit the stop lugs firmly with *attachment screws and washers* according to the figure *Additional stops on page 76*.	Specified in *Required equipment on page 75*. M12x60, tightening torque: 82 Nm, oil lubrication.

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2.4.3. Mechanically restricting the working range of axis 2

Mechanically restricting the working range

The working range of axis 2 can be restricted mechanically by fitting additional mechanical stops (spacers and dampers) to the lower arm and gearbox unit axis 1-3, as detailed in this section. Note that the system parameter configuration must also be adjusted (*Upper joint bound* and *Lower joint bound* for the type *Arm* in the topic *Motion*).

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Mechanical stop, axis 2	3HAC4225-1		Includes spacers, dampers, attachment screws and nuts.
Spacer (damper)	3HAB9185-1		
Spacer	3HAC3962-1		
Standard toolkit		3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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2.4.3. Mechanically restricting the working range of axis 2

Continued

Additional stops

The additional mechanical stops (spacers and dampers) are fitted to the lower arm and the gearbox unit, as shown in the figure below.

xx0300000260

A	View A of the lower arm
B	View B of the lower arm
C	Cut of the mech stop attachment
D	Spacer
E	Attachment screw, spacer (+nut)
F	Damper
G	Attachment screw, damper (+nut)

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Working range

The working range of axis 2 can be restricted according to the table below. The table applies to all robot versions except IRB 4400/FS.

Note! Initial position for the IRB 4450S is +48°

Working range	Damper, qty	Spacer, qty
+95° / -70°	-	-
+95° / -40°	-	2
+95° / -10°	2	2
+65° / -70°	2	-
+65° / -40°	2	2
+65° / -10°	4	2
+35° / -70°	4	-
+35° / -40°	4	2
+35° / -10°	6	2
+5° / -70° (not applicable on IRB 4400/S)	6	-
+5° / -40° (not applicable on IRB 4400/S)	6	2
+5° / -10° (not applicable on IRB 4400/S)	8	2

- Each damper is fitted with: 2 attachment screws and 2 hexagon nuts.
- Each spacer is fitted with: 1 attachment screw and 1 hexagon nut.

Fitting, mechancial stop axis 2

The procedure below details how to fit the additional mechanical stop to the lower arm and the gearbox unit.

Mounting instructions are also supplied with the kit.

	Action	Info/Illustration
1.	Determine the working range restriction.	See *Working range on page 79*.
2.	Fit both the *spacers* to either side of the gearbox unit, with the *attachment screws and nuts, spacer.*	Shown in the figure *Additional stops on page 78*. Art. no. is specified in *Required equipment on page 77*. Attachment screw: 1 pc/spacer, M16x70. Tightening torque: 156 Nm.
3.	Fit the *dampers* to both sides of the lower arm with the *attachment screws and nuts, damper.*	Shown in the figure *Additional stops on page 78*. Art. no. is specified in *Required equipment on page 77*. Attachment screws: 2 pcs/ damper, M10x60. Tightening torque: 49 Nm.

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2.4.4. Electrically restricting the working range of axis 3

Electrically restricting the working range

The working range of axis 3 can be limited by fitting an electric switch on the gearbox for axis 3, which senses the current position via a cam. The system parameter configuration must also be updated.

Electrical stop

All the separate parts of the electrical stop are fitted to axis 3 as shown in the figure below.

xx0300000262

A	Sealing with dust lip (3HAB 3701-14)
B	Stud (2122 2012-867)
C	All screws are locked with locking liquid
D	Tap (3HAB 3798-1)
E	Hexagon nut (9ADA 267-7)
F	Disc (3HAB 3799-1)
G	Screw (9ADA 618-44)
H	Cam (3HAB 3800-1)
I	Bracket (3HAB 8400-1)
J	Limit switch complete (3HAB 8312-1)
K	Screw (9ADA 629-50)
L	Attachment screw (9ADA 183-35)
M	Retaining ring (9ABA 135-18), reducing coupling (2686 015-3), washer (2152 398-3)

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Required equipment

Equipment, etc.	Art. no.	Note
Electrical stop, axis 3	3HAB3795-1	Includes all spare parts shown in the figure *Electrical stop on page 80*.
Locking liquid		Loctite 243
Standard toolkit	3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
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 diagrams		See the chapter *Circuit diagram*.

Fitting, electrical stop axis 3

The procedure below details how to fit the electrical stop to axis 3.

Mounting instructions are also supplied with the kit.

	Action	Info/Illustration
1.	Remove the covers (A) from axis 3.	xx0300000263
2.	All screws are locked with *locking liquid*, when fitted.	Specified in *Required equipment on page 81*.
3.	Fit the electrical stop according to the figure *Electrical stop on page 80*.	
4.	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*.

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2.4.5. Unlimited working range

Resetting the work area for an axis

The function *Resetting the work area for an axis*, included in *Advanced Motions 3.0*, can also be used for axis 4. To enable this function, the mechanical stop on axis 4 should be removed. Follow the procedure below to dismantle the mechanical stop.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

Location of mechanical stop, axis 4

The mechanical stop of axis 4 is located as shown in the figure below.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000176

A	Mechanical stop axis 4
B	Damper axis 4
C	Attachment screws, mechanical stop

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Removal of mechanical stop, axis 4

The procedure below details how to remove the mechanical stop of axis 4, to enable the function *Resetting the work area for an axis*.

WARNING!

When the damper is removed from axis 4, the axis does not have a mechanical stop! If the robot is provided with cabling on the upper arm, the cabling can be damaged when the function *Resetting the work area for an axis* is used, or if the robot is jogged uncalibrated.

	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Loosen the *attachment screws, mech stop* and remove the *mechanical stop, axis 4*.	Shown in the figure *Location of mechanical stop, axis 4 on page 82*.
3.	Slowly rotate axis 4 until the damper is visible through the hole.	
4.	Remove the damper.	
5.	Refit the mechanical stop to the axis 4 with its attachment screws.	4 pcs, M8x16. Tightening torque: 24 Nm.

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2.5 Electrical connections

2.5.1. Customer connection on robot

Location of customer connection

For the connection of extra equipment to the robot, cables and air hose are integrated into the robot´s cabling, and there is one FCI UT071823SH44N and one FCI UT071412SH44N connector on the rear part of the upper arm.

The customer connections are located on the robot as shown in the figure.

xx0300000270

A	R1.CP, R1.CS, Air R1/4"
B	R2.CP, R2.CS, Air R1/4"
C	R3.CP, R3.CS, Air R1/4"

Extra equipment connections

Connections to the:

- air hose (R1/4") is located on the rear part of the upper arm and at the base. Max. 8 bar. Inner hose diameter: 8 mm.
- signal cabling (option) is located on the front of the upper arm.

Number of signals: 23 (50V, 250mA), 10 (250V, 2A), one protective ground.

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Connection sets

To connect power and signal conductors to the robot base/upper arm connectors, the following parts are recommended.

Connection set	Connector	Art. no.	Content
R1.CP/CS (IRB 4400 Protection Standard)	R1.CP/CS	3HAC12275-1	• socket for area of 0.14 - 0.5 mm^2 • compression gland for cables, diameter 2 x 12 mm • key pin
R1.CP/CS F (IRB 4400 Protection Foundry)	R1.CP/CS	3HAC12276-1	• socket for area of 0.14 - 0.5 mm^2 • compression gland for cables, diameters 10 mm and 12 mm • key pin
R2.CS/R3.CS	R2.CS/ R3.CS	3HAC12327-1	• pins for cable area of 0.13 - 0.25 mm^2 • reduction hose, bottled-shaped • reduction hose, angled
R2.CP/R3.CP	R2.CP/ R3.CP	3HAC12326-1	• pins for cable area of 0.13 - 0.25 mm^2 • reduction hose, bottled-shaped • reduction hose, angled

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2.5.2. Customer connections on upper arm

Customer connections on upper arm

The figure shows the customer connections on the upper arm, including the optional signal lamp that can be fitted to the armhouse.

xx0300000269

A	R2.CP
B	R2.CS
C	Signal lamp (option)
D	R3.H1 +, R3.H2 -

Power supply connections on upper arm

Signal name	Customer Terminal Controller	Customer Contact on Upper arm, R2	Customer Contact on robot base (cable between robot and controller not supplied)
CPA	XT6.1	R2.CP.A	RI.CP/CS.A1
CPB	XT6.2	R2.CP.B	RI.CP/CS.B1
CPC	XT6.3	R2.CP.C	RI.CP/CS.C1
CPD	XT6.4	R2.CP.D	RI.CP/CS.D1
CPE	XT6.5	R2.CP.E	RI.CP/CS.A2
CPF	XT6.6	R2.CP.F	RI.CP/CS.B2
		R2.CP.G (Earth)	RI.CP/CSP Earth
	XT6.H	R2.CP.H (Key pin)	
CPJ	XT6.7	R2.CP.J	RI.CP/CS.C2

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Signal name	Customer Terminal Controller	Customer Contact on Upper arm, R2	Customer Contact on robot base (cable between robot and controller not supplied)
CPK	XT6.8	R2.CP.K	RI.CP/CS.D2
CPL	XT6.9	R2.CP.L	RI.CP/CS.A3
CPM	XT6.10	R2.CP.M	RI.CP/CS.B3

Signal connections on upper arm

Signal name	Customer Terminal Controller	Customer Contact on Upper arm, R2	Customer Contact on robot base (cable between robot and controller not supplied)
CSA	XT5.1	R2.CS.A	R1.CS/CP.B5
CSB	XT5.2	R2.CS.B	R1.CS/CP.C5
CSC	XT5.3	R2.CS.C	R1.CS/CP.D5
CSD	XT5.4	R2.CS.D	R1.CS/CP.A6
CSE	XT5.5	R2.CS.E	R1.CS/CP.B6
CSF	XT5.6	R2.CS.F	R1.CS/CP.C6
CSG	XT5.7	R2.CS.G	R1.CS/CP.D6
CSH	XT5.8	R2.CS.H	R1.CS/CP.A7
CSJ	XT5.9	R2.CS.J	R1.CS/CP.B7
CSK	XT5.10	R2.CS.K	R1.CS/CP.C7
CSL	XT5.11	R2.CS.L	R1.CS/CP.D7
CSM	XT5.12	R2.CS.M	R1.CS/CP.A8
CSN	XT5.13	R2.CS.N	R1.CS/CP.B8
CSP	XT5.14	R2.CS.P	R1.CS/CP.C8
CSR	XT5.15	R2.CS.R	R1.CS/CP.D8
CSS	XT5.16	R2.CS.S	R1.CS/CP.A9
CST	XT5.17	R2.CS.T	R1.CS/CP.B9
CSU	XT5.18	R2.CS.U	R1.CS/CP.C9
CSV	XT5.19	R2.CS.V	R1.CS/CP.D9
CSW	XT5.20	R2.CS.W	R1.CS/CP.A10
CSX	XT5.21	R2.CS.X	R1.CS/CP.B10

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2.6 Additional installation (Foundry Prime)

2.6.1. Installation of IRB4400 in a water jet application

General

Robots delivered with the Foundry Prime protection are specially designed to work in water jet cleaning cells with 100% humidity and alkaline detergent. To ensure that the protection offers the best reliability, some measures are needed during installation of the robot according to the procedures below.

NOTE!

For best reliability, it is also of highest importance that the special maintenance instructions for the Foundry Prime robot are followed and documented.

Commissioning

- Never switch off the overpressure in motors and serial measurement compartment during cooling down of robot after it has been switched off.
- When turning off an cleaning cell we recommend that the humid air inside a cell is ventilated out, to avoid that the humid air is sucked into e.g. gearboxes due to the raised vacuum when cooled down.

Environmental conditions

Humidity	100%
Washing detergent with pH	<9.0
Washing detergent must contain rust inhibitor and be approved by ABB.	
Cleaning bath temperature	<60°C, used in a typical waterjet cleaning application at suitable speed.

Air specification for pressurizing of robot

The air must be dry and clean, such as instrument air. Following table details the air specification.

Dew point	<+2°C at 6 bar
Solid particle size	<5 microns
Oil content	<1 ppm (1 mg/m3)
Pressure to robot	0.2-0.3 bar

WARNING!

If the pressurized air contains oil, it could result in a brake failure in the motors and cause the robot arms to fall down, leding to personal injure or physical damage.

WARNING!

If the air pressure exceeds the specified, it could result in a brake failure in the motors and cause the robot arms to fall down, leding to personal injure or physical damage.

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Continued

NOTE!

To secure sufficient air pressure, it is recommended to use a pressure sensor.

Pressurize the motors and serial measurement board cavity

The robots are prepared with hoses to the motors and the serial measurement board cavity to enable pressurizing of them.

WARNING!

The robot must be pressurized also when it is switch off, to avoid that the humid environmental air is sucked into the motors when cooling down.

	Action	Note/Illustration
1.	Connect a compressed air hose to air connector on robot base, see illustration.	xx0600003107 • A: connection to motors
2.	Protect the screws on the Harting connectors on the robot base from corrosion with Mercasol 3106.	Do this when the controller cables are connected.
3.	Pressurize the robot.	See *Air specification for pressurizing of robot on page 88* for correct pressure.
4.	Inspect the air system.	See *Inspection of air hoses (Foundry Prime) on page 99*.

Protecting from high pressure water

WARNING!

No part of the robot should be exposed to direct high pressure jet of water. The sealings between the moving parts on the wrist should not be exposed to direct or rebounding high-pressure jet of water.

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Continues on next page

Protecting the wrist joints

The sealings between the moving parts on the wrist should not be exposed to direct high-pressure water. We recommend that the gripper include a shield that prevents direct water flush on the sealing surfaces of the wrist. The sealings are pointed out in the illustration below.

xx0600003108

A	Axis 5, bearing support side
B	Axis 5, bearing gear side
C	Axis 6, mounting flange - gear house

Protecting the wrist flange from corrosion

The mounting surface on the wrist flange is protected with grease. The joint between the wrist flange and the tool and the screw holes on the wrist flange should be protected.

	Action	Note/Illustration
1.	After mounting the tool, clean the following surfaces from grease: • the visible surface (not painted) • the rear end of the screw holes and end of screws.	 xx0600003109 • screw holes and screws • unpainted surface
2.	Protect these surfaces with Mercasol 3106.	
3.	Before running the robot in a water jet cleaning cell: • perform a inspection of the pressure in motors and SMB cavity.	*Inspection of air hoses (Foundry Prime) on page 99*

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2.6.2. Commissioning (Foundry Prime)

General

The following should be taken in consideration when running a robot in a water jet application cell:

CAUTION!

Never switch off the overpressure in motors and serial measurement compartment during cooling down of robot after it has been switched off.

NOTE!

To reduce the risk for corrosion due to condensation in gearboxes, it is recommendable that the robot is running with high speed on each axes at least on one occasion each hour. This is to lubricate the gearbox cavities.

NOTE!

When turning off a cleaning cell we recommend that the humid air is ventilated out from the cell, to avoid that the humid air is sucked into gearboxes for example, due to the raised vacuum when cooled down.

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2.7 Making robot ready for operation, Clean room

2.7.1. Additional installation procedure, Clean room

General

Clean room robots are specially designed to work in a clean room environment.

Clean room robots are designed in order to prevent from particle emission from the robot. For example is maintenance work possible to perform without cracking the paint. The robot is painted with four layers of polyurethane paint. The last layer being a varnish over labels in order to simlify cleaning.

Clean room parts being replaced must be replaced with parts designed for use in Clean room environments.

Clean room class 5

Particle emission from the robot fulfill Clean room class 5 standard according to DIN EN ISO 14644-1.

Preparations before commissioning a Clean room robot

During transport and handling of a Clean room robot, it is likely that the robot has been contaminated with particles of different kinds. Therefore the robot must be minutely cleaned before installation.

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3 Maintenance

3.1. Introduction

Structure of this chapter

This chapter details all maintenance activities recommended for the manipulator.

It is based on the maintenance schedule located 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, that is, required tools and materials.

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

Safety information

Before any service 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 13* before performing any service work.

NOTE!

If the robot is connected to power, always make sure that the robot is connected to *earth* before starting any maintenance work!

For more information see:

- Product manual - IRC5
- Product manual - IRC5 Compact
- Product manual - Panel Mounted Controller

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3.2 Maintenance schedule

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 manipulator:

- Calendar time: specified in months regardless of whether the manipulator system is run or not
- Operating time: specified in operating hours. More frequent running of the manipulator means more frequent maintenance activities.

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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.

Activities and intervals

The table below specifies the required maintenance activities and intervals.

Maintenance activity	Equipment	Interval	Detailed in section
Replacement	Battery pack, measuring system	Battery low alert [1)]	*Replacement of battery pack, measuring system on page 102*
Replacement	Signal cabling, upper arm (option 042)	12,000 hrs	*Replacement of signal cabling, upper arm (option 042) on page 161*
Inspection	Mechanical stop, axis 1	Regularly [3)]	*Inspection of mechanical stop, axis 1 on page 97*
Change	Oil, gearbox axis 4	12,000 hrs [2)]	*Oil change, gearbox axis 4 on page 111*
Change	Oil, gearbox axes 5 and 6	12,000 hrs [2)]	• *Oil change, gearbox axis 5 and 6 (all robot versions except IRB 4400/L10) on page 114* • *Oil change, gearbox axis 5 and 6 (IRB 4400/L10 only) on page 117*

1. Battery low alert (38213 Battery charge low) is displayed when remaining backup capacity (robot powered off) is less than 2 months. 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 (approx. 3 times) for longer production breaks by a battery shutdown service routine. See Operating manual - IRC5 with FlexPendant for instructions..
2. The gearboxes are lubricated for life, which corresponds to 40,000 hours of operation if the robot is operating with an ambient temperature of less than 40° C. If the temperature is higher, the oil should be changed!
3. Must be replaced if bent!

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Activities and intervals (Foundry Prime application)

Robots working with water jet cleaning and that have the special tightness for this application require special maintenance for proper function. The maintenance must be done according to the maintenance schedule in the Product Manual and the following additional maintenance.

Maintenance activity	Equipment	Interval	Detailed in section
Inspection Replacement	Cable harness	6 months If required [4]	*Replacement of cable harness, axes 1-3 on page 127* or *Replacement of cable harness, axes 4-6 on page 132*
Inspection	Mechanical stop, axis 1	Regularly [3]	*Inspection of mechanical stop, axis 1 on page 97*
Inspection	Air hoses	6 months	*Inspection of air hoses (Foundry Prime) on page 99*
Inspection	Wrist rust protection	6 mths	*Protecting the wrist flange from corrosion on page 90*
Inspection	Surface treatment	6 months [5]	*Inspection of surface treatment (Foundry Prime) on page 101*
Changing	Gear oil axes 1-6	6,000 hrs [2]	*Change and checking of oil on page 106*
Replacement	Battery pack, measuring system	Battery low alert [1]	*Replacement of battery pack, measuring system on page 102*

1. Battery low alert (38213 Battery charge low) is displayed when remaining backup capacity (robot powered off) is less than 2 months. 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 (approx. 3 times) for longer production breaks by a battery shutdown service routine. See Operating manual - IRC5 with FlexPendant for instructions..
2. The gearboxes are lubricated for life, which corresponds to 40,000 hours of operation if the robot is operating with an ambient temperature of less than 40° C. If the temperature is higher, the oil should be changed!
3. Must be replaced if bent!
4. Parts that need to be changed according to the maintenance schedule are not covered by warranty.
5. Damage to painted surfaces must be repaired as soon as possible to avoid corrosion.

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3.3 General maintenance activities

3.3.1. Inspection of mechanical stop, axis 1

Location of mechanical stop

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

xx0300000182

A	Mechanical stop pin, axis 1
B	Set screw

Required equipment

Equipment, etc.	Spare part no.	Note
Mechanical stop, axis 1	3HAB 3647-1	
Standard toolkit		The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

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Inspection

The procedure below details how to inspect the mechanical stop on axis 1

WARNING!

If the mechanical stop has been deformed after a hard collision, it must be replaced!

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Check regularly that the stop pin is not bent or damaged in any other way.	
3.	**NOTE!** If the mechanical stop pin has been deformed or damaged, it must be replaced by a new one!	Removal/refitting of the mechanical stop is detailed in section *Replacement of mechanical stop pin, axis 1 on page 197*.
4.	Also check that the stop pin is properly attached.	

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3.3.2. Inspection of air hoses (Foundry Prime)

General

The air hoses on Foundry Prime robots must be inspected for leakage every six months.

Required equipment

Equipment, etc.	Art. no.
Leak detection spray	-
Pressure gauge	-
Cut off valve	-

Procedure

For this test it is recommended that the air supply to the robot has a pressure gauge and a cut-off valve connected.

	Action	Note
1.	Apply compressed air to the air connector on robot base, and raise the pressure with the knob until the correct value is shown on the pressure gauge.	Recommended pressure: 0.2-0.3 bar xx0600003341 • A: Air Connection • B: Pressure gauge • C: Cut off valve
2.	Close the cut off valve.	It should take at least 5 seconds for the pressure to reach 0 bar.
3.	The time is < 5 seconds: • If the answer is **YES**: Localize the leakage by following the procedures below. • If the anser is **NO**: The system is OK. Remove the leak testing equipment.	
4.	Pressurize by opening the cut off valve.	
5.	Spray suspected leak areas with *leak detection spray*. Bubbles indicate a leak.	

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Continued

	Action	Note
6.	When the leak is localized: correct the leak.	

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3.3.3. Inspection of surface treatment (Foundry Prime)

Introduction to inspection of surface treatment

Damage to painted surfaces must be repaired as soon as possible to avoid corrosion. All painted surfaces on the robot must be inspected.

Required equipment

Equipment, etc.	Spare part no
Touch up paint Foundry Prime, orange	3HAC037052-001
Touch up paint Foundry Prime 2, grey	3HAC035355-001

Inspection and repair of surface treatment

Use this procedure to inspect the surface treatment on Foundry Prime robots.

	Action	Info
1.	Inspect all painted surfaces for damages.	
2.	Repair damages as described in the instruction included in the spare part kit.	

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3.3.4. Replacement of battery pack, measuring system

NOTE!

The SMB lithium battery lifetime can be extended significantly during a production break. Activate sleep mode in IRC5 by a service routine that is described in Operating manual – IRC5 with FlexPendant, chapter *Battery shutdown service routine*.

Location of battery pack

The battery pack is fit to the serial measurement unit, located inside the base. To access the unit and battery pack, the rear cover plate shown in the figure below must be removed.

xx0300000106

A	Rear cover plate

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Battery pack	4944 026-4		Rechargeable nickel-cadmium battery.
Battery pack	3HAC 16831-1		Lithium battery.
Standard toolkit		3HAC 17594-1	The contents are defined in section *Standard toolkit* in the *Product manual, reference information*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Replacement, battery pack

The procedure below details how to replace the battery pack in the serial measurement unit.

Step	Action	Info/Illustration
1.	esd **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 40*	
2.	Set the robot to the MOTORS OFF operating mode. This way the robot does not need to be calibrated after the battery change.	
3.	Remove the *rear cover plate* from the base.	Shown in the figure *Location of battery pack on page 102*.
4.	Loosen the battery terminals from the serial measuring board and cut the clasps that keep the battery pack in place.	
5.	Remove the old battery pack.	
6.	Fit a new *battery pack* with two clasps and connect the terminals to the serial measuring board.	Part no. is specified in *Required equipment on page 102*.

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3.3.5. Cleaning, robot

WARNING!

Turn off all electrical power supplies to the manipulator before entering the manipulators work space!

General

To secure high uptime it is important that the robot is cleaned regularly. The frequency of cleaning depends on the environment that the robot is working in.

Depending on the protection of the robot, different methods of cleaning of the robot are allowed. This section describes how to clean a robot with protection *Standard*, *Foundry Plus* and *Foundry Prime*.

NOTE!

Always check the serial number sign for verification about the robot protection class.

Cleaning activities

This instruction specifies allowed cleaning methods for each protection class.

Cleaning method	Standard	Foundry Plus	Foundry Prime
Vacuum cleaner.	Yes.	Yes.	Yes.
Wipe with cloth.	Yes. With light cleaning detergent.	Yes. With light cleaning detergent or spirit.	Yes. With cleaning detergent approved by ABB, spirit or isopropyl alcohol.
Rinse with water.	Yes. It is highly recommended that water contains a rust prevention solution and that the robot is dried afterwards.	Yes. It is highly recommended that water contains a rust prevention solution.	Yes. It is highly recommended that water contains a rust prevention solution.
High pressure water or steam according to chapter Cleaning with water and steam below.	No.	Yes. It is highly recommended that water and steam contains rust preventive, without cleaning detergents.	Yes. It is highly recommended that water and steam contains rust preventive. If cleaning detergents are used they must be approved by ABB for Foundry Prime robots.

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Cleaning with water and steam

Cleaning methods that can be used for ABB robots with protection *Standard*, *Foundry Plus*, *Wash*, *Foundry Prime*.

Equipment, etc.	Note
Vacuum cleaner	
Cloth with mild detergent	
Water cleaner	• Max. water pressure at the nozzel: 700 kN/m^2 (7 bar) (1) • Fan jet nozzle should be used, min. 45° spread • Distance from nozzle to encapsulation: min. 0.4 m • Flow: max. 20 liters/min (1).
Steam cleaner	• Water pressure at nozzle: max. 2,500 kN/m^2 (25 bar) • Type of nozzle: fan jet, min. 45° spread • Distance from nozzle to encapsulation: min. 0.4 m • Water temperature: max. 80° C

1) Typical tap water pressure and flow

Cables

Movable cables need to be able to move freely:

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

Do's and don'ts!

The section below 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!

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 then 0.4m!
- Never remove any covers or other protective devices before cleaning the robot!

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3.4 Change and checking of oil

3.4.1. Oil in gearbox unit, axis 1-2-3

General

The oil in the gearbox unit, axis 1-2-3, is normally not changed. This section specifies the oil permitted in the unit.

Oil in gears, IRB 4400/45, /60, /L30, /L10 and IRB 4450S

Gear...	Art. no.	Volume	Note
Axis 1	1171 2016-604	8,200 ml	
Axis 2-3	1171 2016-604	5,800 ml	

The lubricating oil specified above corresponds to:

- Mobilgear 600 XP320
- Mobilgear 632

Oil in gears, IRB 4400/FS

Gear...	Art. no.	Volume	Note
Axis 1	1171 2016-604	10,000 ml	
Axis 2-3	1171 2016-604	6,000 ml	

The lubricating oil specified above corresponds to:

- Mobilgear 600 XP320
- Mobilgear 632

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3.4.2. Inspection of oil levels

Location of oil plugs, axes 2 and 3

The oil plug, filling for the gearbox unit, axes 2 and 3, is located as shown in the figure below. The figure shows the location of the axis-2-side and is the same on the opposite side.

Note! The location of these oil plugs on the IRB 4450S is slightly different compared to the other robot versions.

xx0300000331

A	Oil plug, filling

Location of oil plugs, axes 4

The axis 4 gearbox has one oil plug for draining and one oil plug for filling, located as shown in the figure below.

xx0300000220

A	Upper oil plug, filling
B	Lower oil plug, draining

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Location of oil plugs, axes 5 and 6 (all robot versions except IRB 4400/L10)

The wrist unit has two oil plugs for draining and one oil plug for filling, located as shown in the figure below.

xx0300000223

A	Oil plug, draining (2 pcs, the other oil plug not shown in figure)
B	Oil plug, filling (also used for draining)

Location of oil plugs, axes 5 and 6 (only IRB 4400/L10)

The wrist unit has one oil plug for draining the oil and one oil plug for filling, located as shown in the figure below. The oil plug for filling is also used as an air inlet when draining the oil.

xx0300000118

A	Oil plug, draining
B	Oil plug, filling (also used as air inlet when draining)

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Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

Inspection, oil level axis 2-3

The procedure below details how to inspect the oil level of the gearbox unit, axes 2-3.

Step	Action	Note/Illustration
1.	Remove the *oil plug, filling*.	Shown in the figure *Location of oil plugs, axes 2 and 3 on page 107*.
2.	Measure the oil level from the oil plug hole. Required oil level: 225 mm ± 25 mm.	The oil must cover at least half of the lower arm bearing!
3.	Fill or drain, if necessary.	Type of oil is detailed in section *Oil in gearbox unit, axis 1-2-3 on page 106*.
4.	Clean and refit the oil plug.	

Inspection, oil level axis 4

The procedure below details how to inspect the oil level of the gearbox, axis 4.

WARNING!

Changing and draining gearbox oil may require handling hot oil of up to 90 °C! Make sure that protective gear like goggles and gloves are always worn during this activity.

Also, be aware of possible pressure build up in gearbox! When opening the oil plug, there may be pressure present in the gearbox, causing oil to spray from the opening!

WARNING!

When filling gearbox oil, do not mix different types of oil as this may cause severe damage to the gearbox! Always use the type of oil specified by the manufacturer!

If the oils are mixed, the gearbox must be thoroughly rinsed! Contact ABB for further instructions!

Step	Action	Info/Illustration
1.	Move the upper arm to a horizontal position (calibration position).	
2.	Remove the *upper oil plug, filling*.	Shown in the figure *Location of oil plugs, axis 4 on page 107*.

Continues on next page

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Continued

Step	Action	Info/Illustration
3.	Required oil level: 4 mm to the edge of the oil plug hole.	
4.	Fill with *lubricating oil*, if necessary.	Type of oil is detailed in section *Oil change, gearbox axis 4 on page 111*.
5.	Refit the oil plug.	

Inspection, oil level axis 5 and 6 (all robot versions except IRB 4400/L10)

The procedure below details how to inspect the oil level of wrist unit, axis 5 and 6 for all robot versions except IRB 4400/L10.

Step	Action	Note/Illustration
1.	Move the robot to the calibration position.	
2.	Remove one of the *oil plugs, draining* at the rear of the wrist.	Shown in the figure *Location of oil plugs, axes 5 and 6 (all robot versions except IRB 4400/L10) on page 108*.
3.	Required oil level: on level with the edge of the oil plug hole.	
4.	Fill with *lubricating oil*, if necessary	Type of oil is detailed in section *Oil change, gearbox axis 5 and 6 (all robot versions except IRB 4400/L10) on page 114*.
5.	Refit the oil plug.	

Inspection, oil level axis 5 and 6 (IRB 4400/L10)

The procedure below details how to inspect the oil level of wrist unit, axis 5 and 6 for robot version IRB 4400/L10.

Step	Action	Note/Illustration
1.	Move the robot to a position where the upper arm is close to horizontal and axis 4 in the calibration position.	
2.	Remove the *oil plug, filling* from the side of the wrist.	Shown in the figure *Location of oil plugs, axes 5 and 6 (only IRB 4400/L10) on page 108*
3.	Required oil level: on level with the edge of the oil plug hole.	
4.	Fill with *lubricating oil*, if necessary.	Type of oil is detailed in section *Oil change, gearbox axis 5 and 6 (IRB 4400/L10 only) on page 117*.
5.	Refit the oil plug.	

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3.4.3. Oil change, gearbox axis 4

Location of oil plugs

The axis 4 gearbox has one oil plug for draining and one oil plug for filling, located as shown in the figure below.

xx0300000220

A	Upper oil plug, filling
B	Lower oil plug, draining

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Lubricating oil	3HAC 0860-1		Optimol Optigear BM 100 Volume: 3,400 ml.
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Oil collecting vessel			Capacity: 4,000 ml.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Draining

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

TIP!

When changing gearbox oil, first run the robot for a time to heat up the oil. Warm oil drains quicker than cold oil.

WARNING!

Changing and draining gearbox oil may require handling hot oil of up to 90 °C! Make sure that protective gear like goggles and gloves are always worn during this activity.

Also, be aware of possible pressure build up in gearbox! When opening the oil plug, there may be pressure present in the gearbox, causing oil to spray from the opening!

Step	Action	Info/Illustration
1.	Move the arms backward and the upper arm to a nearly vertical position.	
2.	Remove the *lower oil plug, draining* and drain the oil into an oil collecting vessel.	Shown in the figure *Location of oil plugs on page 111*. Capacity of the oil collecting vessel is specified in *Required equipment on page 111*.
3.	Clean and refit the oil plug.	

Filling

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

NOTE!

The specified amount of oil is based on the total volume of the gearbox. When changing the oil, the amount of refilled oil may differ from the specified amount, depending on how much oil has previously been drained from the gearbox.

WARNING!

When filling gearbox oil, do not mix different types of oil as this may cause severe damage to the gearbox! Always use the type of oil specified by the manufacturer!

If the oils are mixed, the gearbox must be thoroughly rinsed! Contact ABB for further instructions!

WARNING!

When filling gearbox oil, do not overfill, since this could lead to internal over-pressure inside the gearbox which in turn may:

- - damage seals and gaskets
- - completely press out seals and gaskets
- - prevent the manipulator from moving freely

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Step	Action	Note/Illustration
1.	Move the upper arm to a vertical position (rear end upwards).	
2.	Remove the *upper oil plug, filling*.	Shown in the figure *Location of oil plugs on page 111*.
3.	Fill the gearbox with *lubricating oil*.	Amount and art. no. is specified in *Required equipment on page 111*. Correct oil level is specified in section *Inspection of oil levels on page 107*.
4.	Clean and refit the oil plug.	

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3.4.4. Oil change, gearbox axis 5 and 6 (all robot versions except IRB 4400/L10)

Location of oil plugs

The wrist unit has two oil plugs for draining and one oil plug for filling, located as shown in the figure below.

xx0300000223

A	Oil plug, draining (2 pcs, the other oil plug not shown in figure)
B	Oil plug, filling (also used for draining)

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Lubricating oil		3HAC 0860-1	Optimol Optigear BM 100 Volume: 3,400 ml
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Oil collecting vessel			Capacity: 4,000 ml
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Draining oil

The procedure below details how to drain the oil from the wrist unit (axis 5 and 6).

TIP!

When changing gearbox oil, first run the robot for a time to heat up the oil. Warm oil drains quicker than cold oil.

WARNING!

Changing and draining gearbox oil may require handling hot oil of up to 90 °C! Make sure that protective gear like goggles and gloves are always worn during this activity.

Also, be aware of possible pressure build up in gearbox! When opening the oil plug, there may be pressure present in the gearbox, causing oil to spray from the opening!

Step	Action	Info/Illustration
1.	Move the upper arm to a horizontal position and turn axis 4 to the calibration position.	
2.	Turn axis 4 135°.	
3.	Remove the lower *oil plug, draining* at the rear of the wrist.	Shown in the figure *Location of oil plugs on page 114*. Capacity of oil collecting vessel is specified in *Required equipment on page 114*.
4.	Remove the other oil plug, draining.	
5.	Move axis 3 up -15° and let the oil run out for a couple of minutes.	
6.	Turn axis 4 so that the *oil plug, filling* is facing downwards.	Shown in the figure *Location of oil plugs on page 114*.
7.	Remove the *oil plug, axis 5* to drain the oil.	
8.	Move axis 3 down to 0°.	
9.	Move axis 4 backwards and forwards a couple of times to drain all the oil.	
10.	Clean and refit the both *oil plugs, draining*.	

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Filling oil

The procedure below details how to fill oil to the wrist unit (axis 5 and 6).

NOTE!

The specified amount of oil is based on the total volume of the gearbox. When changing the oil, the amount of refilled oil may differ from the specified amount, depending on how much oil has previously been drained from the gearbox.

WARNING!

When filling gearbox oil, do not mix different types of oil as this may cause severe damage to the gearbox! Always use the type of oil specified by the manufacturer!

If the oils are mixed, the gearbox must be thoroughly rinsed! Contact ABB for further instructions!

WARNING!

When filling gearbox oil, do not overfill, since this could lead to internal over-pressure inside the gearbox which in turn may:

- - damage seals and gaskets
- - completely press out seals and gaskets
- - prevent the manipulator from moving freely

Step	Action	Note/Illustration
1.	Move the upper arm to a horizontal position and turn axis 4 to calibration position.	
2.	Turn axis 4 so that the *oil plug, filling* is facing upwards.	Shown in the figure *Location of oil plugs on page 114*.
3.	Fill the wrist with *lubricating oil* through the oil plug hole, filling. Fill in intervals so that the oil runs into the wrist.	Art. no. and amount is specified in *Required equipment on page 114*. Correct oil level is specified in section *Inspection of oil levels on page 107*.
4.	Clean and refit the oil plug, filling.	

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3.4.5. Oil change, gearbox axis 5 and 6 (IRB 4400/L10 only)

Location of oil plugs

The wrist unit has one oil plug for draining the oil and one oil plug for filling, located as shown in the figure below. The oil plug for filling is also used as an air inlet when draining the oil.

xx0300000118

A	Oil plug, draining
B	Oil plug, filling (also used as air inlet when draining)

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Lubricating oil		3HAC 0860-1	Optimol Optigear BM 100 Volume: 800 ml
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Oil collecting vessel			Capacity: 1000 ml
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Draining oil

The procedure below details how to drain the oil from the wrist unit (axis 5 and 6), robot version IRB 4400/L10.

TIP!

When changing gearbox oil, first run the robot for a time to heat up the oil. Warm oil drains quicker than cold oil.

WARNING!

Changing and draining gearbox oil may require handling hot oil of up to 90 °C! Make sure that protective gear like goggles and gloves are always worn during this activity.

Also, be aware of possible pressure build up in gearbox! When opening the oil plug, there may be pressure present in the gearbox, causing oil to spray from the opening!

Step	Action	Info/Illustration
1.	Move the upper arm to a horizontal position and turn axis 4 to the calibration position.	
2.	Remove the *oil plug, draining* in the wrist.	Shown in the figure *Location of oil plugs on page 117*.
3.	Turn axis 4 to a position where the *oil plug, draining* is faced downwards and drain the oil into an *oil collecting vessel*. Also remove the *oil plug, filling*, in order to use it as an air inlet.	Shown in the figure *Location of oil plugs on page 117*. Capacity of vessel is specified in *Required equipment on page 117*.
4.	Turn axis 4 another 90° to allow the remaining oil to be drained.	
5.	Clean and refit the oil plug, draining.	

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Filling oil

The procedure below details how to fill oil to the wrist unit (axis 5 and 6), robot version IRB 4400/L10.

NOTE!

The specified amount of oil is based on the total volume of the gearbox. When changing the oil, the amount of refilled oil may differ from the specified amount, depending on how much oil has previously been drained from the gearbox.

WARNING!

When filling gearbox oil, do not mix different types of oil as this may cause severe damage to the gearbox! Always use the type of oil specified by the manufacturer!

If the oils are mixed, the gearbox must be thoroughly rinsed! Contact ABB for further instructions!

WARNING!

When filling gearbox oil, do not overfill, since this could lead to internal over-pressure inside the gearbox which in turn may:

- - damage seals and gaskets
- - completely press out seals and gaskets
- - prevent the manipulator from moving freely

Step	Action	Note/Illustration
1.	Move the upper arm to a horizontal position and turn axis 4 to the calibration position.	
2.	Fill the wrist with *lubricating oil* through the oil plug hole, filling.	Art. no. and amount are specified in *Required equipment on page 117*. Correct oil level is specified in section *Inspection of oil levels on page 107*.
3.	Clean and refit the oil plug, filling.	

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3.4.5. Oil change, gearbox axis 5 and 6 (IRB 4400/L10 only)

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4 Repair

4.1. Introduction

Structure of this chapter

This chapter details all repair activities recommended for the robot and any external units of the robot.

It is made up of separate procedures, each detailing 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 robot.

Required equipment

All equipment required to perform a specific repair activity is listed together with the current procedure.

The equipment is also gathered in different lists in chapter *Reference information*.

Safety information

Before any service work is commenced, it is extremely important that all safety information is read!

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 specific steps in a procedure. Make sure to read through the chapter *Safety on page 13* before commencing any service work.

NOTE!

If the robot is connected to power, always make sure that the robot is connected to *earth* before starting any repair work!

For more information see:

- Product manual - IRC5
- Product manual - Panel Mounted Controller.

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4.2 General procedures

4.2.1. Performing a leak-down test

General

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.	Art. no.	Note
Leakdown tester	3HAC0207-1	
Leak detection spray	-	

Procedure

	Action	Note
1.	Finish the refitting procedure of the motor or gear in question.	
2.	Remove the topmost oil plug on the gear in question and replace it with the *leakdown tester*. Adapters, which are included in the leakdown tester kit, may be required.	Art. no. is specified in *Required equipment on page 122*.
3.	Apply compressed air and raise the pressure with the knob until the correct value is shown on the manometer.	Recommended value: 0.2 - 0.25 bar (20 - 25 kPa)
4.	Disconnect the compressed air supply.	
5.	Wait for approx. 8-10 minutes. No pressure loss may be detected.	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.	Was any pressure drop evident? Localize the leak as detailed below. Remove the leakdown tester and refit the oil plug. The test is complete.	
7.	Spray suspected leak areas with *leak detection spray*. Bubbles indicate a leak.	
8.	When the leak has been localized, take the necessary measures to correct the leak.	

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4.2.2. Mounting instructions for bearings

General

This section details how to mount and grease different types of bearings on the robot.

Equipment

Equipment, etc.	Art. no.	Note
Grease	3HAB3537-1	Used to grease the bearings, if not specified otherwise.

Assembly of all bearings

Follow the instructions below when 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 all parts included in the bearing fitting are free from burrs, grinding waste and other contamination. Cast components must be free from foundry sand.	
3.	Bearing rings, inner rings and roller elements must under no circumstances be subjected to direct impact. Furthermore, the roller elements must not be exposed to any stresses during the assembly work.	

Assembly of tapered bearings

Follow the previous instructions for assembly of all bearings when mounting a tapered bearing on the robot.

In addition to those instructions, the procedure below 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 lifespan of the bearing.	

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Greasing of bearings

The bearings must be greased after assembly in accordance to the instructions below:

- 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.
- 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 detailed below:

- *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.

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4.2.3. Mounting instructions for seals

General

This section details how to mount different types of seals onto the robot.

Equipment

Equipment, etc.	Art. no.	Note
Grease	3HAB3537-1	Used to lubricate the seals.

Rotating seals

The procedure below details 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.	Art. no. is specified in *Equipment on page 125*.
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 procedure below details 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 and in accordance with ABB recommendations.
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 procedure below details 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, etc.	Defective o-rings may not be used.
3.	Check the o-ring grooves. The grooves must be geometrically correct and free from pores and contamination.	Defective o-rings may not be used.
4.	Lubricate the o-ring with grease.	
5.	Tighten the screws evenly when assembling.	

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4.3 Complete robot

4.3.1. Replacement of cable harness, axes 1-3

Location of cable harness, axes 1-3

The cable harness of axes 1-3 is located throughout the axis 1 of the robot as shown in the figure below. Also see the following figure for the view X-X.

Note! The figures show the robot model IRB 4400. But the basic principle of the location of the cable harness axes 1-3 for the IRB 4450S is similair. Cables are longer though.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000111

A	Rear cover plate
B	Connectors at the base. Connectors at the rear cover plate: R1.MP, R1.SMB, R1.CP/CS, R2.MP4-6. Brake release connectors: R2.BU, R2.BU1-3, R2.BU4-6. Connectors at serial measurement unit: R2.SMB, R2.FB1-3, R2.FB4-6.

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Location of cable harness, view X-X

The cable guides in the middle of axis 1 are located as shown in the figure below.

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C	Connection box, motor 1. Connectors at motor 1: R3.MP1, R3.FB1.
D	Connection box, motor 2. Connectors at motor 2: R3.MP2, R3.FB2.
E	Connection box, motor 3. Connectors at motor 3: R3.MP3, R3.FB3.
G	Cable guides in the middle of axis 1
H	Protection plate

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Cable harness, axes 1-3	3HAC5958-1		IRB 4400 all models, (except IRB 4450S)
Cable harness, axes 1-3	3HAC 025479-001		IRB 4450S
Gasket	3HAC 4432-1		Between the motor and the connection box, axes 1, 2 and 3. Replace if damaged.
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Equipment, etc.	Spare part no.	Art. no.	Note
Circuit diagram			See the chapter *Circuit diagram*.
Calibration Pendulum Instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, cabling axes 1-3

The procedure below details how to remove the cable harness from the axes 1-3.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Remove the *rear cover plate*.	Shown in the figure *Location of cable harness, axes 1-3 on page 127*.
3.	Remove the serial measurement unit.	Removal detailed in section *Removal, serial measurement unit on page 192*.
4.	Loosen the connectors *R1.MP1, R2.FB1-3, R2.BU, R2.BU1-3*. Also loosen the earth connections.	Shown in the figure *Location of cable harness, axes 1-3 on page 127*.
5.	Cut all the ties around bundle.	
6.	Remove the cable bracket inside the base.	
7.	Remove the *cable guides* and the *protection plate* in the middle of axis 1.	Shown in the figure *Location of cable harness, view X-X on page 128*.
8.	Remove the covers from the connections boxes for the motors in axes 1-2-3.	
9.	Loosen all the connectors to the motors of axes 1-2-3.	Shown in the figure *Location of cable harness, view X-X on page 128*.
10.	Remove the connection boxes from the motors 1-2-3.	
11.	Feed the cabling up through the middle of axis 1 and remove the complete cabling. **Tip!** Gather the loose cabling and connectors into a package with tape in order to protect the connectors and make the cabling easier to handle.	

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Refitting, cabling axes 1-3

The procedure below details how to refit the cable harness to axes 1-3.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Feed the *cable harness, axes 1-3* through the protection plate and down through the middle of axis 1. **Tip!** Gather the loose cabling and connectors into a package with tape in order to protect the connectors and make the cabling easier to handle.	Part no. is specified in *Required equipment on page 128*
3.	Refit the connection boxes to the motors 1-2-3. Replace the *gaskets* if they are damaged.	Part no. is specified in *Required equipment on page 128*
4.	Reconnect the *connectors* in the motors 1-2-3.	Shown in the figure *Location of cable harness, view X-X on page 128*
5.	Refit the *cable guide* and the *protection plate* in the middle of axis 1.	Shown in the figure *Location of cable harness, view X-X on page 128*
6.	Secure the cabling with straps, according to foldout 3.	See the *Foldouts* in the *Product manual, reference information*.
7.	Refit the cable bracket inside the base.	
8.	Reposition the cabling inside the base according to foldout 4.	See the *Foldouts* in the *Product manual, reference information*.
9.	Reconnect all connectors at the base.	
10.	Refit the serial measurement unit.	Detailed in *Refitting, serial measurement unit on page 193*
11.	Refit the rear cover plate.	Shown in the figure *Location of cable harness, axes 1-3 on page 127*
12.	Refit the covers of the connection boxes.	
13.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.

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Step	Action	Info/Illustration
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 39*.	

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4.3.2. Replacement of cable harness, axes 4-6

Location of cable harness, axes 4-6

The cable harness of axes 4-6 is located throughout the robot as shown in the figure below.

Note! The figures show the robot model IRB 4400. But the location of the cable harness axes 4-6 on the IRB 4450S is basically the same.

Also see the following figure for the view X-X.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

A	Rear cover plate
B	Connectors at the base. Connectors at the rear cover plate: R1.MP, R1.SMB, R1.CP/CS (customer connection), R2.MP4-6. Brake release connectors: R2.BU, R2.BU1-3, R2.BU4-6. Connectors at serial measurement unit: R2.SMB, R2.FB1-3, R2.FB4-6.
F	Connection box, motor 4, 5 and 6. Connectors to the motors at upper arm: R3.MP4, R3.MP5, R3.MP6, R3.FB4, R3.FB5, R3.FB6. Customer connections: R2.CP, R2.CS.
I	Cable bracket inside the lower arm
J	Cable bracket at the upper arm

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Location of cable harness, view X-X

The cable guides in the middle of axis 1 are located as shown in the figure below.

X-X

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C	Connection box, motor 1. Connectors at motor 1: R3.MP1, R3.FB1.
D	Connection box, motor 2. Connectors at motor 2: R3.MP2, R3.FB2.
E	Connection box, motor 3. Connectors at motor 3: R3.MP3, R3.FB3.
G	Cable guides in the middle of axis 1
H	Protection plate

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Cable harness, axes 4-6	3HAC 8304-1		IRB 4400 all models (except IRB 4450S)
Cable harness, axes 4-6	3HAC 025480-001		IRB 4450S
Gasket	3HAB 3676-1		3 pcs Between the motor and the connection box. Replace if damaged.
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Equipment, etc.	Spare part no.	Art. no.	Note
Circuit Diagram			See the chapter *Circuit diagram*.
Calibration Pendulum Instruction			Calibration is detailed in a separate calibration manual enclosed with the calibration tools. Art. no. is specified in section *Document references on page 273*in part 2 of the Product manual.

Removal, cabling axes 4-6

The procedure below details how to remove the cable harness from the axes 4-6.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Remove the cover ot the connection box for motors 4-5-6.	
3.	Remove the rear cover plate.	Shown in the figure *Location of cable harness, axes 4-6 on page 132*
4.	Remove the serial measurement unit.	Detailed in section *Removal, serial measurement unit on page 192*
5.	Loosen the connectors R2.MP4-6, R2.FB4-6, R2.BU4-6, R1.CP/CS. Also loosen the earth connections.	Shown in the figure *Location of cable harness, axes 4-6 on page 132*
6.	Cut all the straps around the bundle.	
7.	Remove the cable bracket inside the base.	
8.	Remove the cable guides and the protection plate in the midle of axis 1.	Shown in the figure*Location of cable harness, view X-X on page 133*

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Step	Action	Info/Illustration
9.	Loosen the cable brackets (A) between gearboxes 2 and 3 and cut the strap around them.	xx0300000113
10.	Feed the cabling and the air hose, if any, up through axis 1. **Tip!** Gather the loose cabling and connectors into a package with tape in order to protect the connectors and make the cabling easier to handle.	
11.	Loosen the cable bracket inside the lower arm and undo the two screws.	Shown in the figure *Location of cable harness, axes 4-6 on page 132*
12.	Loosen the cable bracket at the upper arm.	Shown in the figure *Location of cable harness, axes 4-6 on page 132*
13.	Loosen all the connectors to the motors at the upper arm and customer connections, if any.	Shown in the figure *Location of cable harness, axes 4-6 on page 132*
14.	Remove the connection box together with the cabling.	

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Connection box, upper arm

The figure below shows the location of the motors, connectors and cabling in the upper arm connection box.

xx0300000116

A	Axis 4 motor
A1	Connector R3.MP4
A2	Connector R3.FB4
B	Axis 5 motor
B1	Connector R3.MP5
B2	Connector R3.FB5
C	Axis 6 motor
C1	Connector R3.MP6
C2	Connector R3.FB6
D	Protection plate
E	Cable strap, indoor
F	cable strap, outdoor

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Refitting, cabling axes 4-6

The procedure below details how to refit the cable harness to the axes 4-6.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Check the position of the three *gaskets*, located between the motors and the connection box. Replace them if damaged.	Part no. is specified in *Required equipment on page 133*.
3.	Refit the connection box. Make sure the gaskets are seated properly!	
4.	Reconnect all the connectors and reposition the cabling inside the connection box using straps.	Connectors and correct positioning are shown in the figure *Connection box, upper arm on page 136*.
5.	Refit the *protection plate* in the connection box.	Shown in the figure *Connection box, upper arm on page 136*.
6.	Run the cabling through the lower arm.	
7.	Refit the *cable bracket at the upper arm.*	Shown in the figure *Location of cable harness, axes 4-6 on page 132*.
8.	Refit the *cable bracket inside the lower arm.*	Shown in the figure *Location of cable harness, axes 4-6 on page 132*.
9.	Feed the cabling through the *protection plate* and down through the axis 1.	Shown in the figure *Location of cable harness, view X-X on page 133*.
10.	Refit the cable brackets (A) between the gearboxes of axes 2 and 3 and strap the cabling.	 xx0300000113
11.	Refit the cable bracket inside the base.	
12.	Put straps around the bundle and position the cabling at the base according to foldout 4.	See the *Foldouts on page 289* in the *Product manual, reference information*.
13.	Reconnect all the connectors at the base.	

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Continued

Step	Action	Info/Illustration
14.	Refit the serial measurement unit.	Detailed in *Refitting, serial measurement unit on page 193*.
15.	Refit the *rear cover plate.*	Shown in the figure *Location of cable harness, axes 4-6 on page 132*.
16.	Refit the cover of the connection box in the upper arm.	
17.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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4.3.3. Replacement of complete arm system

Location of complete arm system

The complete arm system includes the lower arm and the complete upper arm, as shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000143

A	Lower arm
B	Upper arm
C	Attachment screws and friction washers, lower arm
D	Parallel arm
E	V-ring between lower arm and gearbox axis 3

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
V-ring	3HAB 3773-11		2 pcs. On both sides of the lower arm, in the frame.
Grease		3HAB 3537-1	Used to grease sealings and bearings.
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.

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Equipment, etc.	Spare part no.	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.
Calibration Pendulum Instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, complete arm system

The procedure below details how to remove the complete arm system from the robot.

Note! The following procedure also applies to the IRB 4450S.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** The complete arm system weighs 232 kg! All lifting equipment used must be sized accordingly!	
3.	Remove the tie rod.	Detailed in section *Replacement of tie rod on page 175*.
4.	Remove the cabling down to axis 1.	Detailed in section *Removal of cable harness, axes 4-6*.

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Step	Action	Info/Illustration
5.	Move the upper arm into a resting position against the lower arm. Lock the upper arm in this position with securing slings around the lower and upper arm (A), as shown in the figure to the right. **Note!** If the arms are not properly secured, the upper arm may move during the lift and cause a drop of the complete arm system.	 xx0300000142 **Note!** The figure shows the IRB 4400. The same position of the upper arm resting against the lower arm, should be applied for the IRB 4450S.
6.	Unload the weight of the arm system with lifting slings and a crane.	
7.	Remove the balancing device.	Detailed in section *Replacement of balancing device on page 183*.
8.	Remove the parallel arm.	Detailed in section *Replacement of parallel arm / Replacement of bearing on page 179*.
9.	Remove the *attachment screws and friction washers, lower arm*.	Shown in the figure *Location of complete arm system on page 139*.
10.	Lift away the complete arm system. Make sure the upper and lower arm are properly secured to each other during the lift.	

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Refitting, complete arm system

The procedure below details how to refit the complete arm system to the robot.

Note! The following procedure also applies to the IRB 4450S.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** The complete arm system weighs 232 kg! All lifting equipment used must be sized accordingly!	
3.	Check and grease both of the *V-rings* in the frame. Replace if damaged.	Part no. is specified in *Required equipment on page 139*
4.	Lift the arm system into mounting position. Make sure the arms are properly secured to each other (A), as shown in the figure to the right.	 xx0300000142 **Note!** The figure shows the IRB 4400. The same position of the upper arm resting against the lower arm, should be applied for the IRB 4450S.

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Continued

Step	Action	Info/Illustration
5.	Secure the arm system to the gearbox axis 2 with the *attachment screws and friction washers.* Make sure both V-rings are seated properly!	10 pcs, M16x55. Tightening torque: 260 Nm. Shown in the figure *Location of complete arm system on page 139*
6.	Grease the bearing seating of the parallel arm in the lower arm, to prevent clicking during operation.	
7.	Refit the parallel arm.	Detailed in section *Refitting, parallel arm/bearing on page 181*
8.	Refit the balancing device.	Detailed in section *Refitting of balancing device on page 188*
9.	Move the upper arm to a horizontal position.	
10.	Refit the tie rod.	Detailed in section *Refitting, tie rod on page 177*
11.	Refit the cabling to the upper arm.	Detailed in section *Refitting, cabling axes 4-6 on page 137*
12.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
13.	**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 39*.	

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4.4 Upper arm

4.4.1. Replacement of complete upper arm

Location of upper arm

The complete upper arm includes the wrist unit and is located as shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000129

A	Upper arm
B	Connectors of motors, axes 4, 5 and 6
C	Connection box, upper arm
D	Calibration plate, axis 3
E	VK cover
F	KM nut
G	Screw
H	Bearing
I	Sealing ring
J	Shaft end

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Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Upper arm, without wrist and motors	3HAC 17542-1		Foundry (also used for standard)
Sealing ring	3HAC 7877-1		
Taper roller bearing	3HAA 2103-13		
VK cover	3HAC 12165-1		
Shaft end	3HAC 4744-1		
Grease		3HAB 3537-1	Used to grease the bearing.
Locking liquid			Loctite 243
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Dismounting tool		3HAC 0163-1	Used to pull out the shaft.
Mounting tool		3HAB 1463-1	Used to fit the inner ring of the bearing. Contains two separate parts.
De-air tool		3HAC 8704-1	Used to evacuate air when refitting VK-cover, if the cover has no grooves for venting.
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.
Calibration Pendulum Instruction			Art. no. is specified in section *Document references on page 273*in part 2 of the Product manual.

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Continues on next page

Removal, upper arm

The procedure below how to remove the complete upper arm from the robot.

Note! The following procedure also applies to the IRB 4450S.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** The complete arm system weighs 232 kg! All lifting equipment used must be sized accordingly!	
3.	Move the upper arm to a horizontal position.	
4.	Secure the weight of the upper arm with the lifting slings and a crane.	
5.	Remove the tie rod.	Detailed in section *Removal, tie rod on page 176*
6.	Loosen the connectors of motors, axes 4, 5 and 6.	Shown in the figure *Location of upper arm on page 144*
7.	Remove the connection box, upper arm from the motors.	Shown in the figure *Location of upper arm on page 144*
8.	Remove the calibration plate, axis 3.	Shown in the figure *Location of upper arm on page 144*
9.	Remove the VK covers on both sides of the upper arm. Be careful with the bearing beneath the cover! Make a hole in the outer edge of the cover and bend it away.	Shown in the figure *Location of upper arm on page 144*
10.	Undo the KM nuts.	Shown in the figure *Location of upper arm on page 144*
11.	Remove the screws.	Shown in the figure *Location of upper arm on page 144*
12.	Pull out the shaft with the dismounting tool. Mark the shafts (left and right)!	Art.no. is specified in *Required equipment on page 145*
13.	Remove the sealings and bearings, if damaged.	Shown in the figure *Location of upper arm on page 144*
14.	Remove the upper arm from the manipulator.	

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Refitting, upper arm

The procedure below details how to refit the complete upper arm to the robot.

Note! The following procedure also applies to the IRB 4450S.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** The complete arm system weighs 232 kg! All lifting equipment used must be sized accordingly!	
3.	Fit the *sealings* and the outer ring of the *bearings* in the upper arm, if removed. The bearing must be completely filled with grease.	Shown in the figure *Location of upper arm on page 144*. Part no. is specified in *Required equipment on page 145*.
4.	Lower the upper arm into mounting position.	
5.	Refit both *shaft ends.*	Shown in the figure *Location of upper arm on page 144*. Part no. is specified in *Required equipment on page 145*.
6.	Insert both *screws.*	Shown in the figure *Location of upper arm on page 144*. 2 pcs, tightening torque: 470 Nm.
7.	If the bearing is removed, the inner ring of the bearing is fitted as follows: • Fit the holding-on tool (part A of the *mounting tool*) on the right side of the upper arm (seen from behind). • Fit the inner ring (C) of the bearing on the left side of the upper arm, using the press tool (part B of the mounting tool). • Remove the holding-on tool and fit the inner ring also on that side.	Art. no. is specified in *Required equipment on page 145*. xx0300000130 • A: Holding-on tool • B: Press tool • C: Inner ring
8.	Apply *locking liquid* on the threads of the *KM nut.*	Locking liquid specified in *Required equipment on page 145* Shown in the figure *Required equipment on page 145*.

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4.4.1. Replacement of complete upper arm

Continued

Step	Action	Info/Illustration
9.	Tighten the KM nut... • on the **left side**, with torque 95 Nm in order to center the upper arm • on the **right side** first with 105 Nm. Then unscrew the KM nut and re-tighten it with torque 95 Nm. **Note!** This procedure must be performed within 10 minutes, before the Loctite begins to harden.	
10.	Fit new *VK covers.* **Note!** If the covers have no grooves for venting, the air must be evacuated by using the *de-air tool (A)*. Also use a clamp as an aid in positioning the covers tilted, to avoid overpressure.	Part no. is specified in *Required equipment on page 145*. Shown in the figure *Location of upper arm on page 144*. xx0300000134 • A: De-air tool, used if the VK-cover has no grooves for venting.
11.	Refit the tie rod.	Detailed in section *Refitting of tie rod*.
12.	Refit the *calibration plate, axis 3.*	Shown in the figure *Location of upper arm on page 144*.
13.	Refit the *connection box.*	Shown in the figure *Location of upper arm on page 144*.
14.	Reconnect the *connectors to motors, axes 4, 5 and 6.*	Shown in the figure *Location of upper arm on page 144*.
15.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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4.4.2. Replacement of wrist unit

Location of wrist unit

The wrist unit is located in the upper arm as shown in the figure below. (The illustration shows the IRB 4400.) Removal/refitting procedures differs depending on robot version.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000150

A	Wrist unit
B	O-ring
C	Sealing surface between wrist unit and upper arm tube
D	Attachment screws and washers

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Wrist unit (IRB 4400/45, /60, /L30, /S and IRB 4450S)	3HAB 8271-1		
Wrist unit (IRB 4400/L10)	3HAB 9398-1		
O-ring (IRB 4400/45, /60, /L30, /S and IRB 4450S)	2152 2012-541		

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Continued

Equipment, etc.	Spare part no.	Art. no.	Note
O-ring (IRB 4400/L10)	3HAB 3772-12		
Grease		3HAB 3537-1	Used to lubricate the o-ring groove.
Flange sealing		1234 0011-116	Loctite 574
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Measuring tool		3HAB 7887-1	Used when mounting the wrist unit to robot version IRB 4400/L10.
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.
Calibration Pendulum Instruction			Art. no. is specified in section *Document references on page 273*in part 2 of the Product manual.

Removal of wrist unit

The procedure below details how to remove the wrist unit from the robot.

NOTE!

This component includes a complete unit comprising motors and gearboxes. It is a replacement unit of complex design and should not normally be serviced on-site. Instead it should be sent to ABB for service.

ABB recommends its customers to carry out only the following servicing and repair work on this unit.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Drain the oil from the wrist unit.	Draining is detailed in sections *Oil change, gearbox axis 5 and 6 (all robot versions except IRB 4400/L10) on page 114*

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Step	Action	Info/Illustration
3.	Remove the attachment screws and washers (A).	xx0300000148 Wrist unit on robot version IRB 4400/45, /60, /L30, /S and IRB 4450S. xx0300000149 Wrist unit on robot version IRB 4400/L10.
4.	Remove the wrist unit from the upper arm.	

Refitting, wrist unit IRB 4400/45, /60, /L30, /S and IRB 4450S

The procedure below details how to refit the wrist unit to robot versions IRB 4400/45, /60, /L30, /S and IRB 4450S.

NOTE!

This component includes a complete unit comprising motors and gearboxes. It is a replacement unit of complex design and should not normally be serviced on-site. Instead it should be sent to ABB for service etc.

ABB recommends its customers carry out **only** the following servicing/repair work on this unit.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Lubricate the o-ring groove in order to position the *o-ring*. Fit the o-ring to the wrist.	Part no. is specified in *Required equipment on page 149*. Shown in the figure *Location of wrist unit on page 149*.

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Continued

Step	Action	Info/Illustration
3.	Apply *flange sealing* to the surface of the wrist that will seal against the upper arm tube.	Specified in *Required equipment on page 149*. Sealing surface shown in the figure *Location of wrist unit on page 149*.
4.	Refit the wrist with attachment screws and washers (A).	 xx0300000148 • A: 8 pcs, M10x35. Tightening torque: 41 Nm.
5.	Fill the wrist unit with oil.	Detailed in section *Oil change, gearbox axis 5 and 6 (all robot versions except IRB 4400/L10) on page 114*.
6.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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Refitting, wrist unit IRB 4400/L10

The procedure below details how to refit the wrist unit to robot version IRB 4400/L10.

NOTE!

This component includes a complete unit comprising motors and gearboxes. It is a replacement unit of complex design and should not normally be serviced on-site. Instead it should be sent to ABB for service etc.

ABB recommends its customers carry out **only** the following servicing/repair work on this unit.

Step	Action	Note/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Lubricate and fit the *o-ring* to the *wrist unit*.	Part no. is specified in *Required equipment on page 149*. Shown in the figure *Location of wrist unit on page 149*.
3.	Move the upper arm to a vertical position, wrist side pointing upwards.	
4.	Refit the wrist unit. Do not tighten the attachment screws!	
5.	Release the brakes on axes 5 and 6 (one at a time) and fit the *measuring tool* at the rear of the motor.	Art. no. is specified in *Required equipment on page 149*.
6.	Push the wrist to locate the smallest play.	Adjustment of play is detailed in section *Refitting of motors axis 5 and 6*. xx0300000153 Upper arm seen from front • A: Gears on drive shaft • B: Gears on wrist

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Step	Action	Note/Illustration
7.	Tighten the attachment screws and washers (A).	 xx0300000149 • A: 6 pcs, M8x30. Tightening torque: 34 Nm.
8.	Check the play by moving axes 5 and 6 by hand.	
9.	Fill the wrist unit with oil.	Detailed in section *Oil change, gearbox axis 5 and 6 (IRB 4400/L10 only) on page 117*.
10.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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4.4.3. Replacement of arm house unit, axis 4

Location of arm house unit

The arm house unit includes the axis 4 housing and the upper arm tube. It is located as shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000183

A	Upper arm tube
B	Axis 4 housing

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Upper arm without wrist and motors	3HAC 17542-1		Foundry, also used for standard.
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Equipment, etc.	Spare part no.	Art. no.	Note
Calibration Pendulum Instruction			Art. no. is specified in section *Document references on page 273*in part 2 of the Product manual.

Replacement, arm house unit

The procedure below details how to replace the arm house unit.

Note! The following procedure also applies to the IRB 4450S.

CAUTION!

Caution!

The complete arm house unit weighs 152 kg! All lifting equipment used must be dimensioned accordingly!

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Remove the wrist unit.	Detailed in section *Removal of wrist unit*.
3.	Remove the motors for axes 4, 5 and 6.	Detailed in section *Removal of motor, axes 4, 5 and 6 on page 216*.
4.	Remove the arm house unit.	Detailed in section *Removal of complete upper arm*.
5.	Fit the new *arm house unit*.	Part no. is specified in *Required equipment on page 155*.
6.	Refit the wrist unit.	Detailed in section *Replacement of wrist unit on page 149*.
7.	Refit the motors for axes 4, 5 and 6.	Detailed in sections • *Refitting of motor, axis 4 on page 218* • *Refitting of motor, axis 5 on page 221* • *Refitting of motor, axis 6 on page 225*

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Step	Action	Info/Illustration
8.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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4.4.4. Replacement of mechanical stop, axis 4

Location of mechanical stop

The mechanical stop of axis 4 is located in the upper arm as shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000176

A	Mechanical stop axis 4
B	Damper axis 4
C	Attachment screws, mechanical stop

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Mechanical stop, axis 4	3HAB 8856-1		
Damper	3HAB 3760-1		
Flange sealing		1234 0011-116	Loctite 574
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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WARNING!

If the mechanical stop has been deformed after a hard collision, it must be replaced!

WARNING!

When the damper is removed from axis 4, the axis does not have a mechanical stop! If the robot is provided with cabling on the upper arm, the cabling can be damaged when the function *Resetting the work area for an axis* is used, or if the robot is jogged uncalibrated.

Removal, mechanical stop

The procedure below details how to remove the axis 4 mechanical stop from the robot.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Remove the *mechanical stop* by removing its *attachment screws.*	Shown in the figure *Location of mechanical stop on page 158*.
3.	Rotate axis 4 so that the *damper* is visible. Remove the damper.	Shown in the figure *Location of mechanical stop on page 158*.

Refitting, mechanical stop

The procedure below details how to refit the axis 4 mechanical stop to the robot.

Step	Action	Note/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Fit the *damper* to the axis 4.	Shown in the figure *Location of mechanical stop on page 158*. Part no. is specified in *Required equipment on page 158*.
3.	Apply *flange sealing* to the stop.	Art. no. is specified in *Required equipment on page 158*.

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Step	Action	Note/Illustration
4.	Fit the *mechanical stop* to the axis 4 with its *attachment screws.*	Shown in the figure *Location of mechanical stop on page 158*. Part no. is specified in *Required equipment on page 158*. 4 pcs, M8x16. Tightening torque: 24 Nm.

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4.4.5. Replacement of signal cabling, upper arm (option 042)

Location of signal cabling, upper arm

The signal cabling (option 042) runs along the upper arm as shown in the figure below.

xx03000000192

A	Wrist bracket
B	Upper arm bracket
C	Front and rear cable holders
D	Plastic hose

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Customer connection axis 4	3HAC 8820-1		Includes signal/power cabling, necessary brackets, holders etc.
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Removal, signal cabling upper arm

The procedure below details how to remove the signal cabling from the upper arm.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Remove the *wrist bracket* and the *upper arm bracket* from the upper arm.	Shown in the figure *Location of signal cabling, upper arm on page 161*.
3.	Remove the *front and rear cable holders* from the tube shaft.	Shown in the figure *Location of signal cabling, upper arm on page 161*.
4.	Disconnect the connectors at the rear of the upper arm.	

Refitting, signal cabling upper arm

The procedure below details how to refit the signal cabling to the upper arm.

Step	Action	Note/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Fit transparent protection tape to the narrow part of the tube shaft. Remove dirt and grease from the surface first!	
3.	Move axis 4 to its calibration position (0°).	
4.	Refit the *wrist bracket* to the upper arm.	Location of the bracket is shown in the figure *Location of signal cabling, upper arm on page 161*. xx0300000193 • A: 2 pcs, M8x12.

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Step	Action	Note/Illustration
5.	Refit the *upper arm bracket* to the upper arm.	Location of the bracket is shown in the figure *Location of signal cabling, upper arm on page 161*. xx0300000194 • B: 3pcs, M8x12.
6.	Slowly rotate axis 4 clockwise to its stop position. Constantly check that the cables are not fully extended! **Note!** If the cables gets fully extended, stop the rotation and let out more cable from the rear cable holder. This is done by loosening the grey holders and pushing ot the cables by hand.	
7.	Complete the rotation. **Note!** Do not tighten the rear cable holder, leave it open!	
8.	First fit the *front cable holder* around the tube shaft. Run the black *plastic hose* through the foot of the holder. Fit the *rear cable holder* around the tube shaft in the same way.	 xx0300000197 • A: Plastic hose • B: Cable holder Also see the figure *Location of signal cabling, upper arm on page 161*.

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Step	Action	Note/Illustration
9.	Move axis 4 from one extreme limit to the other and back again. Caution! **Caution!** Check the cables during movement: • the cables must not be fully extended! • the cables and air hose must not touch any moving parts of the arm! • the fixing rings must always slide smoothly with no excessive pulling!	
10.	Adjust the length of the cables by pushing and pulling the cables through the inner holders, which are still loose. **Note!** When axis 4 is moving, no stretching of the cables should be felt.	
11.	Tighten the holders by hand. Do not use tools.	
12.	Reconnect the connectors at the rear end of the upper arm.	
13.	Connect the air hose.	
14.	Secure the cables and air hose together with cable straps above the motors.	
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 39*.	

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4.4.6. Measuring the play, axis 5

General

After reassembly due to repair work or any other reason, the play in axis 5 and 6 must be checked to ensure the repetition accuracy of the robot positioning. The procedure for axis 5 is detailed below.

Required equipment

Equipment, etc.	Art. no.	Note
Standard toolkit	-	The content is defined in the section *Standard toolkit on page 275*.
Measuring tool, play (IRB 4400/45, /60, /L30, /S and IRB 4450S)	3HAB 1611-6	
Measuring tool, play (IRB 4400/L10)	3HAB 6337-1	
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.

Measurement, axis 5

The procedure below details how to measure the play of axis 5.

NOTE!

The measuring tool and measuring values differ depending on robot version!

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Move the robot to calibration position and turn the axis 4 90°.	
3.	Fit the *measuring tool, play* to the turning disk.	Art. no. is specified in *Required equipment on page 165*.

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4.4.6. Measuring the play, axis 5

Continued

	Action	Info
4.	Apply load F in one direction, as shown in the figure to the right. **NOTE!** Different load and distances for the different robot versions, as specified to the right!	 xx0300000186 **Values for robot version IRB 4400/45, /60, /L30, /S and IRB 4450S:** • A: Measuring tool, play • B: 100mm • C: 140mm • F: 200N **Values for robot version IRB 4400/L10:** • A: Measuring tool, play • B: 140mm • C: 85mm • F: 40N
5.	Remove the load and set the dial indicator to zero.	

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	Action	Info
6.	Apply load F in the opposite direction, as shown in the figure to the right.	 xx0300000187 **Values for robot version IRB 4400/45, /60, /L30, /S and IRB 4450S:** • A: Measuring tool, play • B: 100mm • C: 140mm • F: 200N **Values for robot version IRB 4400/L10:** • A: Measuring tool, play • B: 140mm • C: 85mm • F: 40N
7.	Remove the load and measure the play by reading the dial indicator.	The maximum play allowed at the given distance from the center of axis 5 is, for robot version • IRB 4400/45, /60, /L30, /S and IRB 4450S: **0.20mm** • IRB 4400/L10: **0.08mm**.

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4.4.7. Measuring the play, axis 6

General

After reassembly due to repair work or any other reason, the play in axis 5 and 6 must be checked to ensure the repetition accuracy of the robot positioning. The procedure for axis 6 is detailed below.

Required equipment

Equipment	Art. no.	Note
Standard toolkit	-	The content is defined in the section *Standard toolkit on page 275*.
Measuring tool, play (IRB 4400/45, /60, /L30, /S and IRB 4450S)	3HAB 1611-6	
Measuring tool, play (IRB 4400/L10)	3HAB 6337-1	
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.

Measurement, axis 6

The procedure below details how to measure the play in axis 6.

NOTE!

The measuring tool and measuring values differ depending on robot version!

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Fit the *measuring tool, play* to the turning disk.	Art. no. is specified in *Required equipment on page 168*.

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	Action	Info
3.	Attach a weight (m) at a distance (B) from the wrist flange, in order to avoid the effects of play on axis 5. **NOTE!** Different weight and distance for the different robot versions, as specified to the right!	 xx0300000188 **Values for robot versions IRB 4400/45, /60, /L30, /S and IRB 4450S:** • A: Measuring tool, play • B: 100mm • m: 20 kg **Values for robot version IRB 4400/L10:** • A: Measuring tool, play • B: 140mm • m: 10 kg
4.	Apply load F in one direction. **NOTE!** Different load and distances for the different robot versions, as specified to the right!	 xx0300000189 **Values for robot version IRB 4400/45, /60, /L30, /S and IRB 4450S:** • A: Measuring tool, play • B: 100mm • C: 100mm • F: 100N **Values for robot version IRB 4400/L10:** • A: Measuring tool, play • B: 100mm • C: 150mm • F: 40N
5.	Remove the load and set the dial indicator to zero.	

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4.4.7. Measuring the play, axis 6

Continued

	Action	Info
6.	Apply load F in the opposite direction, as shown in the figure to the right.	 xx0300000190 **Values for robot version IRB 4400/45, /60, /L30, /S and IRB 4450S:** • A: Measuring tool, play • B: 100mm • C: 100mm • F: 100N **Values for robot version IRB 4400/L10:** • A: Measuring tool, play • B: 100mm • C: 150mm • F: 40N
7.	Remove the load and measure the play by reading the dial indicator.	The maximum play allowed at the given distance (B) from the center of axis 6 is, for robot version: • IRB 4400/45, /60, /L30, /S and IRB 4450S: **0.15mm** • IRB 4400/L10: **0.2mm**.

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4.5 Lower arm

4.5.1. Replacement of lower arm

Location of lower arm

The lower arm is located as shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000141

A	Lower arm
B	Attachment screws and friction washers, lower arm
C	Calibration plate, axis 2
D	Damper
E	Parallel arm

Continues on next page

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F	V-ring between lower arm and gearbox axis 3

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Lower arm (IRB 4400/45, /60, /L10, /L30)	3HAC 5955-1		
Lower arm (IRB 4400FS)	3HAC 5956-1		
Lower arm (IRB 4450S)	3HAC 025476-001		
V-ring	3HAB 3773-11		2 pcs On both sides of the lower arm, in the frame.
Grease		3HAB 3537-1	Used to grease sealings and bearings.
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
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.
Calibration Pendulum Instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, lower arm

The procedure below details how to remove the lower arm from the robot.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** The lower arm weighs 68 kg! All lifting equipment used must be sized accordingly!	

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Continued

Step	Action	Info/Illustration
3.	Remove the cabling down to axis 1.	Detailed in section *Removal of cable harness, axes 4-6*.
4.	Remove the complete upper arm.	Detailed in section *Removal of complete upper arm*.
5.	Attach a crane to the lower arm and unload the weight.	
6.	Remove the balancing device.	Detailed in section *Replacement of balancing device on page 183*.
7.	Remove the parallel arm.	Detailed in section *Replacement of parallel arm / Replacement of bearing on page 179*.
8.	Remove the *attachment screws and friction washers, lower arm.*	Shown in the figure *Location of lower arm on page 171*.
9.	Remove the lower arm from the manipulator.	

Refitting, lower arm

The procedure below deatails how to refit the lower arm to the robot.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** The lower arm weighs 68 kg! All lifting equipment used must be sized accordingly!	
3.	Move the damper and the calibration plate from the old to the new *lower arm*.	Part no. is specified in *Required equipment on page 172*
4.	Check and grease both V-rings in the frame. Replace if damaged.	Part no. is specified in *Required equipment on page 172*
5.	Lift the lower arm and lower it into mounting position. Make sure both V-rings stay seated properly!	
6.	Refit the lower arm to the gearbox axis 2 with attachment screws and friction washers, lower arm.	10 pcs. M16x55. Tightening torque: 260 Nm. Shown in the figure *Location of lower arm on page 171*
7.	Grease the bearing seating of the parallel arm in the lower arm, to prevent clicking during operation.	

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Continued

Step	Action	Info/Illustration
8.	Refit the parallel arm.	Detailed in section *Refitting, parallel arm/bearing on page 181*
9.	Refit the balancing device.	Detailed in section *Refitting of balancing device on page 188*
10.	Refit the upper arm.	Detailed in section *Refitting, upper arm on page 147*
11.	Refit the cabling.	Detailed in section *Refitting, cabling axes 4-6 on page 137*
12.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
13.	**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 39*.	

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4.5.2. Replacement of tie rod

Location of tie rod

The tie rod is located as shown in the figure below. (Figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000117

A	Tie rod
B	Attachment screw
C	Washer
D	O-ring
E	Sealing, outside
F	Spherical roller bearing
G	Sealing, inside

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Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Washer	3HAB 3704-1		Replace if damaged.
O-ring	3HAB 3772-23		
Sealing, outside	3HAC 3297-1		
Spherical roller bearing	3HAA 2167-11		
Sealing, inside	3HAC 3990-11		
Grease		3HAB 3537-1	Used to lubricate the shaft on the robot where the tie rod is to be refitted.
Locking liquid			Loctite 243
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Puller tool			2 pcs Used to pull out the tie rod alternately at the upper and lower end if the tie rod.
Press tool		3HAB 1598-1	Used to press in the spherical roller bearing.
Press tool, p-arm		3HAB 1529-1	2 pcs. Used to press on the tie rod alternately at the upper and lower end of the tie rod.
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.
Calibration Pendulum Instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, tie rod

The procedure below details how to remove the tie rod from the robot.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Lock the upper arm in a horizontal position with help of a crane or similar.	

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Step	Action	Info/Illustration
3.	Remove the two *attachment screws*.	Shown in the figure *Location of tie rod on page 175*.
4.	Remove the two *washers, o-rings and sealings, outside* from the tie rod.	Shown in the figure *Location of tie rod on page 175*.
5.	Insert a screw in each center, to be used as a support.	
6.	Use two puller tools to pull out the tie rod, one at the upper and lower end. Pull alternately at the upper end and at the lower end with the puller tools!	
7.	Remove the bearings if they are to be replaced.	The part no. for new bearings is specified in section *Refitting of tie rod*.

Refitting, tie rod

The procedure below details how to refit the tie rod on to the robot.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	If the bearings are to be replaced, fit new *spherical roller bearings* and new *sealings, inside* to the tie rod. Use the *press tool*.	Part/Art. no. is specified in *Required equipment on page 176*
3.	Lift the tie rod to its mounting site. Make sure the tie rod is refitted with the correct end up!	
4.	Grease the shaft on the robot and refit the tie rod on to the robot using two *press tolls for p-arm*. Press alternately at the upper and lower end with the press tools!	Art. no. is specified in *Required equipment on page 176*
5.	Fit the *sealings, outside* to the tie rod.	Part no. is specified in *Required equipment on page 176*
6.	Fit the *o-rings* to the tie rod.	Part no. is specified in *Required equipment on page 176*
7.	Refit the *washers and attachment screws* using *locking liquid*.	Shown in the figure *Location of tie rod on page 175* Locking liquid is specified in *Required equipment on page 176*

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Continued

Step	Action	Info/Illustration
8.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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4.5.3. Replacement of parallel arm / Replacement of bearing

Location of parallel arm

The parallel arm is located on the robot, as shown in the figure below. (The figure shows the IRB 4400.)

The bearing of the parallel arm is shown in the enlarged view.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000128

A	Parallel arm
B	Attachment screw
C	Washer
D	V-ring on parallel arm
E	Bearing
F	Sealing

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Continues on next page

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
V-ring sealing	3HAB 3732-11		
Groove ball bearing	3HAC 10905-1		
Sealing ring	3HAB 3749-1		
Grease		3HAB 3537-1	Used to lubricate the bearings and sealings.
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Lifting tool		3HAB 1412-1	Used to lift the parallel arm.
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.
Calibration Pendulum Instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, parallel arm/bearing

The procedure below details how to remove the parallel arm from the robot during repair work. It also details how to remove the bearing from the parallel arm in order to replace it.

CAUTION!

Caution!

The parallel arm weighs 70 kg (robot version IRB 4400/45 and IRB 4450S) **or** 115 kg (robot version IRB 4400/60, IRB 4400/L30, IRB 4400/L10, IRB 4400/S)! All lifting equipment used must be dimensioned accordingly!

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Remove the tie rod.	Detailed in *Replacement of tie rod on page 175*.
3.	Fit the *lifting tool* to the parallel arm. Unload the arm with a crane.	Art. no. is specified in *Required equipment on page 180*.

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Continued

Step	Action	Info/Illustration
4.	Loosen the attachment screws (A) so that the cabling can be moved slightly.	xx0300000127
5.	Remove the 10 attachment screws and the washer that holds the parallel arm to gearbox axis 3.	
6.	Lift away the parallel arm from the robot.	
7.	If they are to be replaced, remove the bearing and sealings from the parallel arm.	

Refitting, parallel arm/bearing

The procedure below details how to refit the parallel arm on to the robot during repair work. It also details how to fit a new bearing to the parallel arm as replacement.

CAUTION!

Caution!

The parallel arm weighs 70 kg (robot version IRB 4400/45 and IRB 4450S) **or** 115 kg (robot version IRB 4400/60, IRB 4400/L30, IRB 4400/L10, IRB 4400/S)! All lifting equipment used must be dimensioned accordingly!

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Fit the new *V-ring* to the parallel arm.	Part no. is specified in *Required equipment on page 180*
3.	**If the bearing is to be changed:** • Heat the new *groove ball bearing* to 170°C. • Fit the bearing to the parallel arm. **If the old bearing is kept:** • Grease the bearing.	Part no. is specified in *Required equipment on page 180*
4.	Fit the *sealing ring* to the bearing.	Part no. is specified in *Required equipment on page 180*

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Continued

Step	Action	Info/Illustration
5.	Refit the washer and the 10 attachment screws that hold the parallel arm to the gearbox unit.	10 pcs. M16x80, 12.9 quality UNBRAKO. Tightening torque: 260. Reused screws may be used, providing they are lubricated as detailed in section *Screw Joints* in the Product manual, reference information, before fitting.
6.	Move the upper arm to a horizontal position with a crane (if not already positioned horizontal) and refit the tie rod.	Detailed in section *Refitting, tie rod on page 177*
7.	Reposition the cabling and tighten the cable attachment screws.	 xx0300000127
8.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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4.6 Frame and base

4.6.1. Replacement of balancing device

Location of balancing device

The balancing device is located as shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000100

A	Balancing device
B	Bracket
C	Attachment screws, bracket (M12x50)
D	Press out hole
E	Front screws
F	Fork
G	End part of shaft

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Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Balancing device (IRB 4400/45, /60, /L10, /L30	3HAC 15083-1		Includes balancing device 3HAC 3702-1 Includes cylindrical roller bearing 3HAC 4334-2 Includes front screws 3HAC 6456-1
Balancing device (IRB 4400/FS)	3HAC 15083-2		Includes balancing device 3HAC 3738-1 Includes cylindrical roller bearing 3HAC 4334-2 Includes front screws 3HAC 6456-1
Balancing device (IRB 4450S)	3HAC025477-001		
Sealing ring with dust lip	3HAB 3701-26		
Grease		3HAC 3537-1	Used to lubricate: the bearings at the balancing device brackets (min. 500 ml. in each bearing) the sealing at the balancing device brackets the bearing at the balancing device fork
Nipple			Used to lubricate the bearing at hte balancing device fork. The lubrication hole is dimensioned M10.
Standard toolkit		3HAC 17594-1	The contents are defined in section *Standard toolkit* in the *Product manual, reference information*.
Securing front screws			M10x40H H= threaded to the head. Used to unload the balancing device before removal.
Press tool, bearing		3HAC 5465-1	Used to fit the cylidrical roller bearings and the sealings into the brackets.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Removal, balancing device

The procedure below details how to remove the balancing device.

Step	Action	Info/Illustration
1.	**WARNING!** *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!	
2.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
3.	**CAUTION!** The complete arm system weighs 232 kg! All lifting equipment used must be sized accordingly!	
4.	Move the manipulator to the calibration position, as shown in the figure to the right.	 xx0300000088 • A: Approximately 2º

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Step	Action	Info/Illustration
5.	Remove the two securing screws (A), located at the *fork* of the balancing device. Also remove the plate (C) which secures that the bushing (D) is held in position.	 xx0300000089 The fork is shown in the figure *Location of balancing device on page 183*.
6.	Unload the balancing device by replacing the two front screws (A) with two *securing front screws*. Unload the device level by fastening the securing screws parallel with each other.	 xx0300000095 Dimension specified in *Required equipment on page 184*!
7.	Check that the piston is unloaded by moving it manually.	

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Step	Action	Info/Illustration
8.	Remove the four *attachment screws, bracket* from the bracket at the right side of the balancing device (A), seen from above.	Shown in the figure *Location of balancing device on page 183*! xx0300000098
9.	Remove the bracket from the frame by pressing it out using a M10x30 screw in the *press out hole*.	Shown in the figure *Location of balancing device on page 183*!
10.	Remove the balancing device by pushing it to the side. **Note!** The balancing device weighs 50 kg!	xx0300000099
11.	If the balancing device is to be replaced with a new device, the bracket on the right side must be removed and fitted to the new device.	

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Refitting of balancing device

The procedure below details how to refit the balancing device.

Step	Action	Info/Illustration
1.	**WARNING!** *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!	
2.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
3.	**CAUTION!** The complete arm system weighs 232 kg! All lifting equipment used must be sized accordingly!	
4.	Fit the cylindrical roller bearings and sealings to the balancing device and brackets if • the *balancing device* is a new spare part • the old bearings/sealings are damaged.	The procedure is detailed in *Fitting of cylindrical roller bearing on page 190* Part no. is specified in *Required equipment on page 184*
5.	Lift the balancing device to its mounting position.	If the balancing device is a new spare part, it must be unloaded as described in *Removal, balancing device on page 185*
6.	Fit the balancing device to the left *bracket* and put the fork into correct position.	Shown in the figure *Location of balancing device on page 183*
7.	Refit the right bracket with *attachment screws, bracket* .	4 pcs: M12x50, tightening torque: 82 Nm Shown in the figure *Location of balancing device on page 183*
8.	Refit the original protection screws in the *press out holes* in both the brackets.	2 pcs. MC6S M10x12 8.8 fzb. Shown in the figure *Location of balancing device on page 183*

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Step	Action	Info/Illustration
9.	Lubricate the bearing at the fork: • Remove the two stop screws (B). • Fill with grease through one of the lubrication holes, until excessive grease is forced out through the second hole. Use a nipple! • Refit the two stop screws. • Refit the plate with one screw M8x16 (C). This plate secures the bushing (D) is held in its position.	 xx0300000089 A: Securing screws (2 pcs) B: Stop screws, M10 x 40 (2 pcs) C: Plate and screw M8 x 16 (1 pc) D: Bushing
10.	Before restoring the balancing device, check that: • the fork is in position • the fork does not cover the lubrication holes of the shaft!	The fork is shown in the figure *Location of balancing device on page 183*
11.	Restore the balancing device by removing the replacement front screws (A) and refitting the original protection front screws.	 xx0300000095 2 pcs: MC6S M10x12 8.8 fzb
12.	Refit the fork to the shaft in the lower arm, by refitting the two securing screws (A) at the fork of the balancing device. Make sure that the fork does **not** cover the lubrication holes of the shaft!	Shown in the figure above in *Refitting of balancing device on page 188*

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Continued

Step	Action	Info/Illustration
13.	**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 39*.	

Fitting of cylindrical roller bearing

The procedure below details how to fit the cylindrical roller bearings onto the balancing device shaft and into the frame brackets.

Step	Action	Info/Illustration
1.	Fit the inner ring of the bearing onto both *end parts of the balancing devices shaft* .	Shown in the figure *Location of balancing device on page 183*
2.	Fit the outer ring of the bearing into both brackets with a *press toll, bearing*.	Art. no. is specified in *Required equipment on page 184*
3.	Fit the *sealing ring with dust lip* with the same, but turned, *press tool, bearing*.	Part no. is specified in *Required equipment on page 184*
4.	Lubricate the bearing and the sealing with *grease*.	Art. no. and amount specified in *Required equipment on page 184*
5.	**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 39*.	

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4.6.2. Replacement of serial measurement unit

Location of serial measurement unit

The serial measurement unit is located inside the base of the robot, behind the rear cover, as shown in the figure below.

xx0300000106

A	Rear cover plate

Different versions, serial measurement unit

There are two versions of the serial measurement unit. They are compatible but designed differently, as shown in the figure below.

Note! The battery pack is not compatible between the versions!

xx0300000105

(1)	Old version of serial measurement unit
(2)	New version of serial measurement unit
A	R2.SMB
B	R2.FB4-6
C	R2.FB1-3
D	Fastening plate
E	Battery pack

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Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Serial measurement unit, version	3HAC 17396-1		Includes battery 3HAC16831-1
Serial measurement unit, version	3HAC 16014-1		Does not include battery.
Battery pack, new version	3HAC 16831-1		
Battery pack, old version	4944 026-4		
Fastening plate, new version		3HAC 17395-1	
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
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 the chapter *Circuit diagram*.

Removal, serial measurement unit

The procedure below details how to remove the serial measurement unit.

Step	Action	Note/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	esd **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 40*	
3.	Remove the *rear cover plate* from the base.	Shown in the figure *Location of serial measurement unit on page 191*.
4.	Cut all the straps.	
5.	Unscrew the nuts that attaches the serial measurement unit inside the base.	
6.	Remove the serial measurement unit.	

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Step	Action	Note/Illustration
7.	Remove the connectors from the board.	The connectors are shown in the figure *Different versions, serial measurement unit on page 191*.

Refitting, serial measurement unit

The procedure below details how to refit the complete serial measurement unit.

Step	Action	Note/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	esd **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 40*	
3.	Refit the connectors to the *serial measurement unit*.	Art. no. is specified in *Required equipment on page 192*. The connectors are shown in the figure *Different versions, serial measurement unit on page 191*.
4.	Refit the serial measurement unit inside the base using nuts.	
5.	Strap the cables.	
6.	Refit the *rear cover plate* on the base.	Shown in the figure *Location of serial measurement unit on page 191*.
7.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.

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4.6.3. Replacement of pushbutton unit for brake release

Location of pushbutton unit

The pushbutton unit for brake release is located in the base of the robot, as shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000106

A	Rear cover plate

Connectors on pushbutton unit

The connectors X8, X9 and X10 are placed on the pushbutton unit as shown in the figure below.

xx0300000201

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Pushbutton unit	3HAC 0017-1		
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
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.
Calibration Pendulum Instruction			Art. no. is specified in section *Document references on page 273* in part 2 of the Product manual.

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Removal, pushbutton unit

The procedure below details how to remove the pushbutton unit from the robot.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	esd **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 40*	
3.	Secure the robot by moving... • the lower arm to one of its end positions • the upper arm to its end position.	
4.	Remove the *rear cover plate.*	Shown in the figure *Location of pushbutton unit on page 194*.
5.	Remove the connectors *X8, X9 and X10* from the pushbutton unit.	Shown in the figure *Connectors on pushbutton unit on page 194*.
6.	Remove the pushbutton unit by removing its attachment screws.	

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Refitting of pushbutton unit

The procedure below details how to refit the pushbutton unit to the robot.

Step	Action	Note/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	esd **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 40*	
3.	Refit the new *pushbutton unit* with its attachment screws.	Part no. is specified in *Required equipment on page 194*.
4.	Refit the connectors *X8, X9 and X10* to the pushbutton unit.	Shown in the figure *Connectors on pushbutton unit on page 194*.
5.	Refit the *rear cover plate* to the base of the robot.	Shown in the figure *Location of pushbutton unit on page 194*.
6.	Recalibrate the robot!	Calibration with the pendulum is detailed in the *Calibration Pendulum Instruction,* enclosed with the calibration toolkit. Other calibration is detailed in section *Calibration information on page 247*.
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 39*.	

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4.6.4. Replacement of mechanical stop pin, axis 1

Location of mechanical stop pin

The mechanical stop pin on axis 1 is located on the frame as shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000182

A	Mechanical stop pin, axis 1
B	Set screw

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Mechanical stop, axis 1	3HAB 3647-1		
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Replacement, mechanical stop pin

The procedure below details how to replace the mechanical stop pin on axis 1.

WARNING!

If the mechanical stop has been deformed after a hard collision, it must be replaced!

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Remove the *set screw*.	Shown in the figure in *Location of mechanical stop pin on page 197*.
3.	Remove the old *mechanical stop pin*.	Shown in the figure in *Location of mechanical stop pin on page 197*.
4.	Refit the new *mechanical stop* with the set screw.	Part no. is specified in *Required equipment on page 197*. M10x12

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4.7 Motors

4.7.1. Replacement of motor, axis 1

Location of motor

The motor, axis 1, is located as shown in the figure below. (The figure shows the IRB 4400.)

The motor and the drive gear constitute one unit.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000154

A	Motor, axis 1
B	Connection box with cover
C	Attachment screws and washers

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor unit, axis 1 (IRB 4400/45, /60, /L10, /L30)	3HAC 5952-1		Elmo Includes motor pinion.
Motor unit, axis 1 (IRB 4400/S)	3HAC 9841-1		Elmo Includes motor pinion.
Motor unit, axis 1 (IRB 4400/45, /60, /L10 and IRB 4450S)	3HAC021724-001		Yaskawa Includes pinion
Motor unit, axis 1 (IRB 4400/L30)	3HAC021725-001		Yaskawa Includes pinion
Motor unit, axis 1 (IRB 4400/S)	3HAC021729-001		Yaskawa Includes pinion

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Continued

Equipment, etc.	Spare part no.	Art. no.	Note
O-ring, motor	2152 0431-11		
Flange sealing		1234 0011-116	Loctite 574
Gasket	3HAC 4432-1		Between the motor and the connection box. Replace if damaged!
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Power supply			24 VDC, 1.5 A Used in order to release the brakes.
Measuring toll		3HAB 7887-1 or 3HAB 1408-1	Choose one of the tools.
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 the chapter *Circuit diagram*.
Calibration Pendulum Instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, motor axis 1

The procedure below details how to remove the motor, axis 1.

DANGER!

If a shelf-mounted robot version is **not** flat mounted, the manipulator can contain a living force!

Removing the motor from axis 1 may result in movement of the axis, because the brake is released.

To avoid this, move the robot into normal calibration position or move axis 1 to get the lowest location of the center of gravity for the upper arm.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	

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	Action	Info
2.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
3.	Remove the *cover of the connection box*.	Shown in the figure *Location of motor on page 199*.
4.	Disconnect all the connectors in the motor.	
5.	Remove the *connection box*.	Shown in the figure *Location of motor on page 199*.
6.	Remove the *attachment screws and washers* of the motor. **NOTE!** Check the position of the motor label before removing the motor! The motor must be mounted back at the same position!	Shown in the figure *Location of motor on page 199*.
7.	Remove the motor.	

Refitting, motor axis 1

The procedure below details how to refit the motor, axis 1.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
3.	**NOTE!** The motor units from Elmo and Yaskawa are not compatible!	

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4.7.1. Replacement of motor, axis 1

Continued

	Action	Info
4.	Check that the assembly surfaces are clean from paint, lubricant etc. Make sure that the motor and the gearbox are not damaged or scratched.	
5.	Fit the *o-ring* to the new motor unit.	Part no. is specified in *Required equipment on page 199*
6.	Release the brake of the motor by connecting the 24 VDC power supply.	Connect to connector R3.MP1 • +24V: pin 7 • 0V: pin 8.
7.	Apply *flange sealing* to the motor flange.	Art. no. is specified in *Required equipment on page 199*
8.	Place the new motor in the gearbox. Do not damage the pinion and the gear-wheel! Note the position of the motor! The motor label should be mounted in the same position as it had before removal.	
9.	Fit the upper and lower screws (A, B) and tighten until there is no space between the motor flange and the gearbox. There should be a big backlash between the motor pinion and the gear.	 xx0300000155 A: Lower screw B: Upper screw C: Pushing direction
10.	**NOTE!** Adjust the motor before continuing the refitting procedure!	Adjustment detailed in section *Adjustment of motors, axes 1-3 on page 214*
11.	Fit the other two attachment screws and washers.	Total 4 pcs. M10x30. Tightening torque: 60 Nm.

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Continued

	Action	Info
12.	Check the oil level. Fill with oil if necessary	Detailed in section *Inspection of oil levels on page 107*
13.	Refit the connection box. Replace the gaskets if they are damaged!	Part no. is specified in *Required equipment on page 199*
14.	Reconnect all the connectors.	
15.	Refit the cover of the connection box.	
16.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
17.	**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 39*.	

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4.7.2. Replacement of motor, axis 2

Location of motor

The motor, axis 2, is located as shown in the figure below. (The figure shows the IRB 4400.)

The motor and the drive gear constitute one unit.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000159

A	Motor, axis 2
B	Connection box
C	Attachment screws and washers

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor unit, axis 2 (IRB 4400 -all versions)	3HAC5954-1		Elmo Includes pinion
Motor unit, axis 2 (IRB 4400 - all versions and IRB 4450S)	3HAC021725-001		Yaskawa Includes pinion
O-ring	21520431-11		
Flange sealing		12340011-11	Loctite 574
Standard toolkit		3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
Power supply			24 VDC, 1,5 A Used in order to release the brakes.

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Continued

Equipment, etc.	Spare part no.	Art. no.	Note
Measuring tool		3HAB7887-1 3HAB1408-1	Choose one of the two tools.
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 the chapter *Circuit diagram*.
Calibration Pendulum Instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, motor axis 2

The procedure below details how to remove the motor, axis 2.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Danger! Secure the arm system before removing the motor! The brake is located in the motor and is therefore released when the motor is removed.	
3.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
4.	Remove the cover of the connection box.	
5.	Disconnect all the connectors in the motor.	
6.	Remove the *connection box*.	Shown in the figure *Location of motor on page 204*.

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	Action	Info
7.	**NOTE!** Check the position of the motor label before removing it. The motor must be mounted in the same position.	
8.	Remove the *attachment screws and washers* of the motor. **NOTE!** Oil will start to run out when removing the motor!	Shown in the figure *Location of motor on page 204*.
9.	Remove the motor.	

Refitting, motor axis 2

The procedure below details how to refit the motor, axis 2.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
3.	**NOTE!** The motor units from Elmo and Yaskawa are **not** compatible!	
4.	Check that the assembly surfaces are clean from paint, lubricant etc. Make sure that the motor and the gearbox are not damaged or scratched.	
5.	Mount the o-ring to the new motor unit.	Part no. is specified in *Required equipment on page 204*
6.	Release the brake of the motor by connecting the 24 VDC power supply.	Connect to connector R3.MP2 • +24V: pin 7 • 0V: pin 8
7.	Apply flange sealing to the motor flange.	Art. no. is specified in *Required equipment on page 204*

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	Action	Info
8.	Place the new motor in the gearbox. Do not damage the pinion or the gear wheel! **NOTE!** Check the position of the motor! The motor label should be mounted in the same position as it had before the removal.	
9.	Fit the upper and lower screws (A, B) and tighten until there is no space between the motor flange and the gearbox. There should be a big backlash between the motor pinion and the gear.	 xx0300000160 A: Upper screw B: Lower screw C: Pushing direction
10.	**NOTE!** Adjust the motor before continuing the refitting procedure!	Adjustment is detailed in section *Adjustment of motors, axes 1-3 on page 214*
11.	Fit the other two *attachment screws and washers.*	Shown in the figure *Location of motor on page 204* 2 pcs: M10x70 2 pcs: M10x30 Tightening torque: 60 Nm
12.	Refill with oil.	Detailed in *Oil in gearbox unit, axis 1-2-3 on page 106*
13.	Refit the connection box.	Shown in the figure *Location of motor on page 204*
14.	Reconnect the connectors.	
15.	Refit the cover of the connection box.	
16.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.

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	Action	Info
17.	**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 39*.	

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4.7.3. Replacement of motor, axis 3

Location of motor

The motor, axis 3, is located as shown in the figure below. (The figure shows the IRB 4400.)

The motor and the drive gear constitute one unit.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000163

A	Motor, axis 3
B	Connection box
C	Attachment screws and washers, motor

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor unit, axis 3 (IRB 4400 all versions)	3HAC5954-1		Elmo Includes pinion
Motor unit, axis 3 (IRB 4400 all versions and IRB 4450S)	3HAC021725-001		Yaskawa Includes pinion
O-ring	21520431-11		
Flange sealing		12340011-116	Loctite 574
Standard toolkit		3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
Power supply			24 VDC, 1.5 A To be used for releasing the brakes.

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Equipment, etc.	Spare part no.	Art. no.	Note
Measuring tool		3HAB7887-1 3HAB1408-1	Choose one of the two tools.
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 the chapter *Circuit diagram*.
Calibration Pendulum Instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, motor axis 3

The procedure below details how to remove the motor, axis 3.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**DANGER!** Secure the upper arm system before removing the motor from axis 3! The brake is located in the motor and is therefore released when the motor is removed.	
3.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
4.	Remove the cover from the connection box.	
5.	Disconnect all the connectors in the motor.	
6.	Remove the *connection box* from the motor.	Shown in the figure *Location of motor on page 209*.
7.	**NOTE!** Check the position of the motor label before removing it! The motor must be mounted in the same position.	

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	Action	Info
8.	Remove the *attachment screws and washers, motor.* **NOTE!** Oil will start to run out when removing the motor!	Shown in the figure *Location of motor on page 209*.
9.	Remove the motor.	

Refitting. motor axis 3

The procedure below details how to refit the motor, axis 3.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
3.	**NOTE!** The motor units from ELMO and YASKAWA are not compatible!	
4.	Check that the assembly surfaces are clean from paint, lubricant etc. Make sure that the motor and the gearbox are not damaged or scratched.	
5.	Fit the *o-ring* to the new *motor unit.*	Part no. is specified in *Required equipment on page 209*
6.	Release the brake of the motor by connecting the 24 VDC power supply.	Connect to connectorR3.MP3 • +24V: pin 7 • 0V: pin 8
7.	Apply *flange sealing* to the motor flange.	Art. no. is specified in *Required equipment on page 209*

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	Action	Info
8.	Place the new motor in the gearbox. Do not damage the pinion and the gear wheel!	**NOTE!** Check the position of the motor! The motor label should be mounted in the same position as it had before the removal.
9.	Fit the upper and lower screws (A, B) and tighten until there is no space between the motor flange and the gearbox. There should be a big backlash between the motor pinion and the gear.	 xx0300000160 Motor axis 2, is shown in the figure! A: Upper screw B: Lower screw C: Pushing direction
10.	Note! Adjust the motor before continuing the refitting procedure!	Adjustment is detailed in section *Adjustment of motors, axes 1-3 on page 214*
11.	Fit the other two *attachment screws and washers, motor.*	Shown in figure *Location of motor on page 209* M10x70 M10x30 Tightening torque: 60 Nm
12.	Refill with oil.	Detailed in *Oil in gearbox unit, axis 1-2-3 on page 106*
13.	Refit the *connection box.*	Shown in the figure *Location of motor on page 209*
14.	Reconnect the connectors.	
15.	Refit the cover of the connection box.	
16.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.

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	Action	Info
17.	**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 39*.	

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4.7.4. Adjustment of motors, axes 1-3

General

This section details how to adjust the motors during refitting. It applies to the motors in axes 1, 2 and 3 and is a complement to the refitting instructions found in sections

- *Refitting of motor, axis 1*
- *Refitting of motor, axis 2*
- *Refitting of motor, axis 3*.

Required equipment

Equipment, etc.	Art. no.	Note
Standard toolkit	3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
Measuring tool	Either 3HAB7887-1 or 3HAB1408-1	Choose one of the tools. They are all compatible with the motor.
Power supply		24 VDC, 1.5 A For releasing the brakes.
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 the chapter *Circuit diagram*.

Adjustment

The procedure below details how to adjust the motors during refitting.

	Action	Info
1.	Lock the motor brake before mounting the adjustment tool.	
2.	Fit the *measuring tool* to the motor axis.	Art. no. is specified in *Required equipment on page 214*.
3.	Release the brake of the current motor by connecting the 24VDC supply.	Axis 1 motor: connect to connector R3.MP1 • +24V: pin 7 • 0V: pin 8. Axis 2 motor: connect to connector R3.MP2 • +24V: pin 7 • 0V: pin 8. Axis 3 motor: connect to connector R3.MP3 • +24V: pin 7 • 0V: pin 8.

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	Action	Info
4.	Rotate the motor shaft with the measuring tool. Measure the torque in both directions with a spring balance. A normal torque is 0.6-0.8 Nm (=6-8 N on radius 100 mm). Torques higher than 0.8 Nm are not allowed, as they will reduce the lifetime of the motor and gear.	
5.	Loosen the lower and upper screws until the motor can be moved sideways by hand.	**NOTE!** The brake must be released in the motor.
6.	Push the motor with one hand against the gear and tighten the two screws with the other hand.	
7.	Measure the torque with the motor shaft in different positions. The torque should be max. 0.1 Nm (on radius 50 mm) more than measured before. If the torque is more, • slightly loosen the screws a little and carefully knock the motor in the opposite direction • then measure the torque again. Check that the backlash is very limited, by moving the tool back and forward in small movements. When turning the motor shaft, a tick-tack sound can be heard from the brake disc[1]. This should not be mixed up with the backlash. The difficult part is to find the motor position where the torque just starts to increase.	[1]The brake disc is mounted on the motor shaft with a type of splined coupling. Between the splines there is a narrow backlash. **NOTE!** There should always be a backlash, but it should be as minimal as possible.
8.	Remove the measuring tool.	
9.	Disconnect the brake release voltage.	
10.	Continue refitting the motor.	*Refitting, motor, axis 1* *Refitting, motor, axis 2* *Refitting, motor, axis 3*

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4.7.5. Removal of motor, axes 4, 5 and 6

Location of motors

The motors, axes 4, 5 and 6, are located as shown in the figure below. (The figure shows the IRB 4400.)

The motor and the drive gear of each axis constitute one unit.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000164

A	Motor unit, axis 4
B	Motor unit, axis 5
C	Motor unit, axis 6
D	Attachment screws and washers, motor
E	Connection box

Required equipment

Equipment, etc.	Art. no.	Note
Standard toolkit	3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
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 the chapter *Circuit diagram*.

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Removal, motor axes 4, 5 and 6

The procedure below details how to remove the motors of axes 4, 5 and 6.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**DANGER!** Secure the arm system before removing any motor! The brake is located in the motor and is therefore released when the motor is removed!	
3.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
4.	Drain the oil from the gearbox.	Draining is detailed in sections: • *Oil change, gearbox axis 4 on page 111*. • *Oil change, gearbox axis 5 and 6 (all robot versions except IRB 4400/L10) on page 114* • *Oil change, gearbox axis 5 and 6 (IRB 4400/L10 only) on page 117*.
5.	Remove the cover of the connection box.	
6.	Disconnect all the connectors in the connection box.	
7.	Remove the *connection box.*	Shown in the figure *Location of motors on page 216*.
8.	**NOTE!** Check the position of the motor before removing it. The motor must be mounted back at the same position.	
9.	Remove the *attachment screws and washers, motor.*	Shown in the figure *Location of motors on page 216*.
10.	Remove the motor.	

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4.7.6. Refitting of motor, axis 4

Location of motor

The motors, axes 4, 5 and 6, are located as shown in the figure below. (The figure shows the IRB 4400.)

The motor and the drive gear of each axis constitute one unit.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000164

A	Motor unit, axis 4
B	Motor unit, axis 5
C	Motor unit axis 6
D	Attachment screws and washers, motor
E	Connection box

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor unit, axis 4 (IRB 4400 all versions)	3HAC10603-1		Elmo Includes pinion.
Motor unit, axis 4 (IRB 4400/45, /60, /L30, /S and IRB 4450S)	3HAC021726-001		Yaskawa Includes pinion
Motor unit, axis 4 (IRB 4400/L10)	3HAC021962-001		Yaskawa Includes pinion
O-ring	21522012-426		

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Continued

Equipment, etc.	Spare part no.	Art. no.	Note
Gasket	3HAC3676-1		3 pcs Between the motors and the connection box. Replace if damaged.
Standard toolkit		3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
Measuring tool		3HAB1409-1	
Power supply			24VDC, 1.5A Used to release the brake of the motor.
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 the chapter *Circuit diagram*.
Calibration Pendulum Instruction			Art. no. is specified in section *Document references on page 273*in part 2 of the Product manual.

Refitting, motor axis 4

The procedure below details how to refit the motor, axis 4.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
3.	**NOTE!** The motor unit from ELMO and YASKAWA are **not** compatible!	

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Continued

	Action	Info
4.	Check that the assembly surfaces are clean from paint, lubricant etc. Make sure that the motor and the gearbox are not damaged or scratched.	
5.	Fit the *o-ring* to the new *motor unit.*	Part no. is specified in *Required equipment on page 218*.
6.	Fit the *measuring tool* to the rear of the motor.	Art. no. is specified in *Required equipment on page 218*.
7.	Release the brake of the motor by connecting the 24 VDC power supply.	Connect to connector R3.MP4 • +24V: pin 7 • 0V: pin 8.
8.	Place the new motor unit in the gearbox. Do not damage the pinion or the gear wheel.	
9.	Find the position with the least play by turning the motor shaft 10 revolutions, noting changes in play as you turn the motor.	
10.	Push the motor in a radial direction so that the play is minimal within one motor revolution without the gear "chewing".	
11.	Refit the motor with its *attachment screws and washers, motor.*	Shown in the figure *Location of motor on page 218*. 4 pcs, M6x25. Tightening torque: 15 Nm.
12.	Refill with oil, if drained.	Detailed in section *Oil change, gearbox axis 4 on page 111*.
13.	Check the position of the three *gaskets,* located between the motors and the connection box. Replace them if damaged.	Part no. is specified in *Required equipment on page 218*.
14.	Refit the *connection box.* Make sure the gaskets are seated properly!	Shown in the figure *Location of motor on page 218*.
15.	Reconnect all the connectors.	
16.	Refit the cover to the connection box.	
17.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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4.7.7. Refitting of motor, axis 5

Location of motor

The motors, axes 4, 5 and 6 are located as shown in the figure below. (The figure shows the IRB 4400.)

The motor and drive gear of each axis constitutes one unit.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000164

A	Motor unit, axis 4
B	Motor unit, axis 5
C	Motor unit, axis 6
D	Attachment screws and washers, motor
E	Connection box

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor unit, axis 5 (IRB 4400/45, /60, /L30, /S)	3HAC10603-1		Elmo Includes pinion.
Motor unit, axis 5 (IRB 4400/L10)	3HAC10605-1		Elmo Includes pinion.
Motor unit, axis 5 (IRB 4400/45, /60, /L30, /S and IRB 4450S)	3HAC021726-001		Yaskawa Includes pinion
Motor unit, axis 5 (IRB 4400/L10)	3HAC021962-001		Yaskawa Includes pinion

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Equipment, etc.	Spare part no.	Art. no.	Note
O-ring	21522012-426		
Gasket	3HAC3676-1		3 pcs Between the motor and the connection box. Replace if damaged.
Standard toolkit		3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
Measuring tool		3HAB1409-1	
Power supply			24VDC, 1.5A 2 pcs, used to release the brakes in the motors for axes 4 and 5.
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 the chapter *Circuit diagram*.
Calibration Pendulum Instruction			Art. no. is specified in section *Document references on page 273*in part 2 of the Product manual.

Refitting, motor axis 5

The procedure below details how to refit the axis 5 motor.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
3.	**NOTE!** The motor units from ELMO and YASKAWA are **not** compatible!	

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Continued

	Action	Info
4.	Check that the assembly surfaces are clean from paint, lubricant etc. Make sure that the motor and the gearbox are not damaged or scratched.	
5.	Fit the *o-ring* into the new motor.	Part no. is specified in *Required equipment on page 221*.
6.	Fit the *measuring tool* to the rear of the motor.	Art. no. is specified in *Required equipment on page 221*.
7.	Release the brakes in the motors for axes 4 and 5, by connecting the 24 VDC power supply.	Connect to connector R3.MP4/MP5 • +24V: pin 7 • 0V: pin 8.
8.	Place the new motor unit in the gearbox. Do not damage the pinion or the gear wheel.	
9.	Find the position of least play by turning the outgoing shaft for axis 4 in intervals of 90°, one revolution in all, to locate the area where the play for the motor axis 5 is the smallest.	
10.	Turn the motor for axis 5 one full revolution at a time, five revolutions in all. Find the smallest play within this range.	
11.	Push the motor in a radial direction so that the play is minimal within one motor revolution without the gear "chewing".	
12.	Refit the motor with its *attachment screws and washers, motor.*	Shown in the figure *Location of motor on page 221*. 4 pcs, M6x25. Tightening torque: 15 Nm.
13.	Refill with oil, if drained.	Detailed in section: • *Oil change, gearbox axis 5 and 6 (all robot versions except IRB 4400/L10) on page 114* • *Oil change, gearbox axis 5 and 6 (IRB 4400/L10 only) on page 117*.
14.	Check the position of the three *gaskets*, located between the motors and the connection box. Replace them if damaged.	Part no. is specified in *Required equipment on page 221*.
15.	Refit the *connection box.* Make sure the gaskets are seated properly!	Shown in the figure *Location of motor on page 221*.
16.	Reconnect all the connectors.	
17.	Refit the cover on the connection box.	
18.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.

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	Action	Info
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 39*.	

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4.7.8. Refitting of motor, axis 6

Location of motor

The motors, axes 4, 5 and 6, are located as shown in the figure below. (The figure shows the IRB 4400.)

The motor and the drive gear of each axis constitute one unit.

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000164

A	Motor unit, axis 4
B	Motor unit, axis 5
C	Motor unit, axis 6
D	Attachment screws and washers, motor
E	Connection box

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Motor unit, axis 6 (IRB 4400/45, /60, /L30, /S)	3HAC10604-1		Elmo Includes pinion.
Motor unit, axis 6 (IRB 4400/L10)	3HAC10605-1		Elmo Includes pinion.
Motor unit, axis 6 (IRB 4400/45, /60, /L30, /S and IRB 4450S)	3HAC021728-001		Yaskawa Includes pinion
Motor unit, axis 6 (IRB 4400/L10)	3HAC021962-001		Yaskawa Includes pinion

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Equipment, etc.	Spare part no.	Art. no.	Note
O-ring	21522012-426		
Gasket	3HAC3676-1		3 pcs Between the motors and the connection box. Replace if damaged.
Standard toolkit		3HAC17594-1	The content is defined in the section *Standard toolkit on page 275*.
Measuring tool		3HAB1409-1	
Power supply			24VDC, 1.5A 3 pcs, used to release the brakes in the motors for axes 4, 5 and 6.
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 the chapter *Circuit diagram*.
Calibration Pendulum Instruction			Art. no. is specified in section *Document references on page 273*in part 2 of the Product manual.

Refitting, motor axis 6

The procedure below details how to refit the axis 6 motor.

	Action	Info
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** Whenever parting/mating motor and gearbox, the gears may be damaged if excessive force is used!	
3.	**NOTE!** The motor units from ELMO and YASKAWA are **not** compatible!	

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	Action	Info
4.	Check that the assembly surfaces are clean from paint, lubricant etc. Make sure that the motor and the gearbox are not damaged or scratched.	
5.	Fit the *o-ring* to the new *motor unit*.	Part no. is specified in *Required equipment on page 225*.
6.	Fit the *measuring tool* at the rear of the motor.	Art. no. is specified in *Required equipment on page 225*.
7.	Release the brakes in the motors for axes 4, 5 and 6, by connecting the 24 VDC power supply.	Connect to connector R3.MP4/MP5/MP6 • +24V: pin 7 • 0V: pin 8.
8.	Place the new motor unit in the gearbox. Do not damage the pinion or the gear wheel!	
9.	Find the position of least play by turning the outgoing shaft for axis 4 in intervals of 90°, one revolution in all, to locate the area where the play for the axis 6 motor is the smallest.	
10.	Turn the motor for axis 5 one full revolution at a time, five revolutions in all. Find the least play for axis 6 within this range.	
11.	Turn the motor for axis 6 one full revolutipon at a time, three turns in all. Find the least play for axis 6 within this range.	
12.	Push the motor in a radial direction so that the play is minimal within one motor revolution without the gear "chewing".	
13.	Refit the motor with its *attachment screws and washers, motor.*	Shown in the figure *Location of motor on page 225*. 4 pcs, M6 x 25. Tightening torque: 15 Nm.
14.	Refill with oil, if drained.	Detailed in section • *Oil change, gearbox axis 5 and 6 (all robot versions except IRB 4400/L10) on page 114*. • *Oil change, gearbox axis 5 and 6 (IRB 4400/L10 only) on page 117*.
15.	Check the position of the three *gaskets*, located between the motors and the connection box. Replace them if damaged.	Part no. is specified in *Required equipment on page 225*.
16.	Refit the *connection box*. Make sure the gaskets are seated properly!	Shown in the figure *Location of motor on page 225*.
17.	Reconnect all the connectors.	
18.	Refit the cover on the connection box.	

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	Action	Info
19.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
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 39*.	

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4.8 Gearboxes

4.8.1. Replacement of gearbox unit, axes 1-2-3

General

The gearboxes of axes 1-2-3 are handled as one complete unit. Except for the gearboxes, the spare part also includes motor units and lubricating oil for the axes 1, 2 and 3.

Location of gearbox unit

The gearbox unit, axes 1-2-3, is shown in the figure below. (The figure shows the IRB 4400.)

A more detailed view of the component and its position may be found in chapter *Foldouts* in the *Product manual, reference information*.

xx0300000174

A	Gearbox unit axes 1-3, spare part
B	Bottom plate
C	Attachment screws and washers, gearbox unit
D	Sealing

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Gearbox unit, axes 1-3 (IRB 4400/45, /60, /L10, /L30)	3HAC 5948-1		Does not include motors and lubricating oil.
Gearbox unit, axes 1-3 (IRB 4400/S)	3HAC 5949-1		Does not include motors and lubricating oil.
Gearbox unit, axes 1-3 (IRB 4450S)	3HAC 025482-001		Does not include motors and lubricating oil.
Sealing	3HAC 5479-2		Replace if damaged!

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Equipment, etc.	Spare part no.	Art. no.	Note
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Lifting slings with hoisting block			Lifting capacity: 500 kg.
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.
Calibration Pendulum instruction			General calibration information is included in the section *Calibration information on page 247*.

Removal, gearbox unit

The procedure below details how to remove the gearbox unit, axis 1-2-3, including the motors, from the robot.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** The gearbox unit weighs 360 kg (robot version IRB 4400/45, /60, /L30, /L10 and IRB 4400/S) **or** 475 kg (robot version IRB 4450S)! All lifting equipment used must be sized accordingly!	
3.	**CAUTION!** The base weighs 130 kg! All lifting equipment used must be sized accordingly!	
4.	Remove the cable harness and serial measuring board.	Detailed in sections *Replacement of cable harness, axes 1-3 on page 127*, *Removal of cable harness, axes 4-6* and *Replacement of serial measurement unit on page 191*.

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Step	Action	Info/Illustration
5.	Remove the tie rod.	Detailed in section *Replacement of tie rod on page 175*.
6.	Remove the parallel arm.	Detailed in section *Replacement of parallel arm / Replacement of bearing on page 179*.
7.	Remove the complete arm system.	Detailed in section *Replacement of complete arm system on page 139*.
8.	Unfasten the robot from the foundation.	
9.	Fit and secure straps (A) around the rear part of the gearbox unit, as shown in the figure to the right. Attach the straps to lifting slings with a hoisting block. Fit and secure hooks to the lifting lugs (B). Use the same crane for both attachment points.	 xx0300000172 This figure shows the IRB 4400. xx0500002136 This figure shows the IRB 4450S.
10.	Lift the gearbox unit together with the base and use the hoisting block to tip the complete assembly forward 90°.	

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Step	Action	Info/Illustration
11.	Place the assembly on a level surface and support it at position A, according to the figure on the right. Make sure the unit is stable and rests securily before removing the lifting equipment. **Note!** The figure shows the IRB 4400 but the procedure for the IRB 4450S is the same.	 xx0300000173 • B: Approximately 200 mm (IRB 4400 all models) • B: Approximately 230 mm (IRB 4450S)
12.	Remove the *bottom plate* from the base.	Shown in the figure *Refitting, complete arm system on page 142*.
13.	Move the lifting straps to the base and unload its weight.	
14.	Remove the *attachment screws and washers, gearbox unit.*	Shown in the figure *Refitting, cabling axes 1-3 on page 130*.
15.	Remove the base from the gearbox unit.	
16.	Remove the sealing from the gearbox unit.	

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Refitting, gearbox unit

The procedure below details how to refit the gearbox unit, including motors, to the robot.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	**CAUTION!** The gearbox unit weighs 360 kg (robot version IRB 4400/45, /60, /L30, /L10 and IRB 4400/S) **or** 475 kg (robot version IRB 4450S)! All lifting equipment used must be sized accordingly!	
3.	**CAUTION!** The base weighs 130 kg! All lifting equipment used must be sized accordingly!	
4.	Place the new *gearbox unit* on a level surface and support it at position A, according to the figure on the right. Make sure the unit is stable and rests securily on the surface, including the weight of the base that is to be refitted. **Note!** The figure shows the IRB 4400 but the procedure for the IRB 4450S is the same.	 xx0300000173 Part no. is specified in *Required equipment on page 229* B: Approximately 200mm (IRB 4400 all models) B: Approximately 230 mm (IRB 4450S)

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Step	Action	Info/Illustration
5.	Refit the *sealing* to the gearbox unit. Replace it if damaged.	Shown in figure *Location of gearbox unit on page 229* Part no. is specified in *Required equipment on page 229*
6.	Raise the base and fit it to the gearbox unit. Align the hole pattern of the base to the gearboxes. Turn the gear if necessary by the motor pinion, axis 1.	
7.	Refit the base with the *attachment screws and washers, gearbox unit.*	Shown in figure *Location of gearbox unit on page 229* 14 pcs, M16x80. 12.9 quality UNBRAKO. Tightening torque: 260 Nm. Reused screws may be used, providing they are lubricated as detailed in Screw joints in the Product manual, reference information before fitting.
8.	Refit the *bottom plate* with its attachment screws.	Shown in the figure *Location of gearbox unit on page 229*
9.	Strap the gearbox unit as in the removal instruction	See section *Removal, gearbox unit on page 230*
10.	Lift the gearbox unit together with the base and use the hoisting block to tip the complete assembly backward by 90°, into normal mounting position.	
11.	Refit the robot to the foundation.	
12.	Refit the complete arm system.	Detailed in section *Refitting, complete arm system*
13.	Refit the parallel arm.	Detailed in section *Refitting, parallel arm/bearing on page 181*
14.	Refit the tie rod.	Detailed in section *Refitting, tie rod on page 177*
15.	Refit the cable harness and serial measuring board.	Detailed in sections *Refitting, cabling axes 1-3 on page 130*
16.	Recalibrate the robot!	Calibration is detailed in a separate calibration manual enclosed with the calibration tools. General calibration information is included in the section *Calibration information on page 247*.
17.	**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 39*.	

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4.8.2. Adjusting play on axis 4, intermediate gear

Illustration, adjusting play

In order to adjust the play on axis 4, the gear must be accessible. The figure below shows the parts in the upper arm housing that must be removed/unlocked.

xx0300000191

A	Cover
B	Attachment screws, cover
C	Screws, 3 pcs

Required equipment

Equipment, etc.	Spare part no.	Art. no.	Note
Flange sealing		1234 0011-116	Loctite 574
Standard toolkit		3HAC 17594-1	The content is defined in the section *Standard toolkit on page 275*.
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.			These procedures include references to the tools required.

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Adjusting play, axis 4

The procedure below details how to adjust the play for the intermediate gear of axis 4.

Step	Action	Info/Illustration
1.	**DANGER!** Turn off all electric power, hydraulic and pneumatic pressure supplies to the robot! For Foundry Prime robots: Do not turn off the air pressure to motors and SMB.	
2.	Remove the motors for axes 4, 5 and 6.	Detailed in section *Removal of motor, axes 4, 5 and 6 on page 216*.
3.	Remove the *cover*.	Shown in the figure *Illustration, adjusting play on page 235*.
4.	Unlock the three *screws*.	Shown in the figure *Illustration, adjusting play on page 235*.
5.	Rotate axis 4 to find the highest position of the gear on the upper arm tubular.	
6.	Tighten the three screws again.	3 pcs, tightening torque: 69 Nm.
7.	Apply *flange sealing* to the cover and refit it with its *attachment screws and washers*.	Art. no. is specified in *Required equipment on page 235*. 10 pcs: M8x40. Tightening torque: 24 Nm.

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4.9 Additional repair routines (Foundry Prime)

4.9.1. Introduction

Overview

Robots working with Water jet cleaning have special tightness for water jet cleaning application and require special repair routines to maintain the tightness level. The repair must be done according to the Repair chapter with the following additions as described in the *Repair routines* procedure below.

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4.9.2. Repair routines

Overview

Follow the instruction in the Repair chapter, with the following additional measure.

Equipment	Article number
Cable strap	21662055-3
Sikaflex 521FC	3HAC026759-001
Drill diameter 8.8 mm	

Replacement of motor axes 1-3

The following procedure details how to replace motors axes 1-3.

	Action	Note
1.	Apply Sikaflex 521FC on both sides of the gasket between motor and cable box before mounting the cable box.	 xx0600003111 • A: Sikaflex • B: Gasket
2.	Cut the projecting part of the gasket with a knife.	
3.	Apply Sikaflex 521FC outside the gasket and the cover plate around the motor.	 xx0600003112 • A: Sikaflex

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	Action	Note
4.	Apply Sikaflex 521FC underneath the cover attachment screw heads.	xx0600003113 • A: Sikaflex

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Replacement of cable harness to motor axes 1-3 and 4-6

The following procedure details how to replace motor cabling axes 1-3 and 4-6.

	Action	Note
1.	Drill and tap holes in the cable boxes for the air fittings before mounting a new cable harness. Drill diameter: 8.8mm Thread: 1/8" pipe thread	Cable box, motor unit axes 1-3 xx0600003114 • A: Air connection on motor cable box axis 1. • B: Air connection on motor cable box axis 2 and 3 (not used earth connection. Cable box, motor unit axes 4-6 xx0600003115 • A: Air connection on motor cable box axis 4-6

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Replacement of balancing device

The following procedure details how to replace the balancing device.

	Action	Note
1.	Before mounting the balancing device in the robot, apply Mercasol 3106 on both side of the ear and both side of the washers.	 xx0600003123 • A: Mercasol 3106

Replacement of air hose (Required equipment)

xx0600003342

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Equipment	Article number	
Elbow fitting	3HAC026511-001/ 1	Pos 6 in figure above
Rubber clamp	3HAC026523-001	
T-plug connector	3HAC026515-001/ 2	Pos 3 in figure above
Y-plug connector	3HAC026514-001/ 3	Pos 2 in figure above
Bulkhead plug connector	3HAC026513-001/ 1	Pos 1 in figure above
Air hose	3HAC026526-001	According to table: Pneumatic house Length 7500 mm
Straight plug connector	3HAC026516-001/ 1	Pos 4 in figure above
Straight fitting	3HAC026507-001/ 4	Pos 5 in figure above
Adapter	3HAC027569-001/ 1	Pos 7 in figure above

Pneumatic house	Article number 3HAC026526-001	Note
A	140 mm	From the Bulkhead plug in the front plate to the T-plug connector for the SMB box, se step 1 and 2 in *Replacement of air hose on page 243*
B	270 mm	From the T-plug connector to the stright plug connector in the SMB box.
C	3050 mm	From the T-plug connector through the base and up to the Y-plug connector at the motors of axis 4,5,6, se step 3-5 in *Replacement of air hose on page 243*.
D	40 mm	From the Y-plug connector at axis 4,5,6 motors to the straight fitting in the motor cover axis 4,5,6.
E	1750 mm	From the Y-plug connector at axis 4,5,6 motors to the the Y-plug connector at for the motors of axis 3, se step 6 in *Replacement of air hose on page 243*.

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Pneumatic house	Article number 3HAC026526-001	Note
F	425 mm	From the Y-plug connector at axis 3 motors to the straight fitting in the motor cover axis 3.
G	80 mm	From the Y-plug connector at axis 3 to the Y-plug connector for the balancing cylinder.
H	460 mm	From the Y-plug connector for the balancing cylinder to the elbow fitting in the bak of the balancing cylinder, se step 7 in *Replacement of air hose on page 243*.
K	220 mm	From the Y-plug connector for the balancing cylinder to the T-plug connector for axis 1 and axis 2.
L	140 mm	From the T-plug connector to the straight fitting in the motor cover axis 1.
M	365 mm	From the T-plug connector to the straight fitting in the motor cover axis 2.
N	150 mm	To the Bulkhead plug in the front plate.

Replacement of air hose

The following procedure details how to replace the air hose.

	Action	Note
1.	-The air is let in via the cover of the rear side of the foot where a bulkhead plug for Ø6mm plastic hose is mounted. -A Plastic hose is drawn from the bulkhead plug to a T-plug connector and led to the SMB-compartment.	 xx0600003116
2.	The hose is drawn through a drilled hole in the rubber sealing and firmly tightened with a straight fitting.	 xx0600003117

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	Action	Note
3.	In the base an extra ring of the hose is made so that full movement for axis 1 is guaranteed.	xx0600003118
4.	-The plastic hose is drawn from the T-plug connector up through axis 1.-A hole is drilled in the cable guide axis 1 for the air hose. A bulkhead is mounted in the hole to prevent wear on the hose. -The hose must be able to run free in the bulkhead.	xx0600003119
5.	The hose continue through the lower arm and is connected to a Y-plug connector at the upper arm housing.	xx0600003119

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	Action	Note
6.	The hose is led back down the lower arm to motors axis 1-3 from the Y-plug connector. The air is distributed via a Y-plug connector and a T-plug connector to the cable boxes	 xx0600003120 xx0600003122
7.	From the Y-plug connector for the balancing cylinder to the elbow plug in the back of the balancing cylinder.	 xx0600003344

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5 Calibration information

5.1. Introduction

General

This chapter includes general information about different calibration methods and also details procedures that do not require specific calibration equipment.

When the robot system must be recalibrated, it is done according to the documentation enclosed with the calibration tools.

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. The different methods are briefly described in the section *Calibration methods on page 248*, and further detailed in separate calibration manuals.

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 254*. 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 robot is changed for other reachability, 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.

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5.2. 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 home position, that is the axes' positions (angles) are set to 0º. Standard calibration data is found on the SMB (serial measurement board) 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.	Calibration Pendulum (standard method) or Levelmeter calibration (alternative method)
Absolute Accuracy calibration (optional)	Based on standard calibration, and besides positioning the robot at home 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 absacc 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

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Calibration methods

Each calibration method is detailed in a separate manual. Below is a brief description of the methods available.

Calibration Pendulum - standard method

Calibration Pendulum is the standard method for calibration of all ABB robots (except IRB 6400R, IRB 640, IRB 1400H and IRB 4400S) and is also the most accurate method for the standard type of calibration. It is the recommended method in order to achieve proper performance.

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 for *Calibration Pendulum*, which describes the method and the different routines further.

Levelmeter Calibration - alternative method

Levelmeter Calibration is referred to as the alternative method for calibration of ABB robots because of the less accurate values obtained during calibration. The method uses the same principles as Calibration Pendulum but does not have as good of mechanical tolerances to the toolkit parts as the standard method with Calibration Pendulum.

This method may, after calibration, require modifications in the robot program and is therefore not recommended.

The calibration equipment for Levelmeter Calibration is ordered as separate parts for each robot and the operating manual for *Levelmeter Calibration* is enclosed with the Levelmeter 2000.

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 *Absolute Accuracy Calibware Field 5.0*.

If a service operation is done to a robot with 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 276*.

The calibration equipment for Calibration Pendulum is delivered as a complete toolkit, including *Operating manual - Calibration Pendulum*, which describes the method and the routines further.

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5.3. Calibration scale and correct axis position

Introduction

This section specifies the calibration scale positions and/or correct axis position for all robot models.

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Calibration scales, IRB 4450S

The illustration below shows the calibration scale positions on IRB 4450S.

The calibration marks for axes 2, 3, 4 and 5 are marked using punch mark tools.

xx0500002239

A	Punch axis 2, 3HAB 1521-1
B	Punch axis 3, 3HAB 1522-1
C	Punch axis 4, 3HAB 1523-1 (there are two different versions of the marks, as shown in the figure)
D	Punch axis 5, 3HAB 1524-1
E	Axes 5 and 6, IRB 4400/L10

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Continued

Calibration scales, IRB 4400

The illustration shows the calibration scale positions on IRB 4400.

The calibration marks for axes 2, 3, 4 and 5 are marked using punch mark tools.

xx0300000209

A	Punch, axis 2, 3HAB 1521-1
B	Punch, axis 3, 3HAB 1522-1
C	Punch, axis 4, 3HAB 1523-1 (there are two different versions of the marks, as shown in the figure)
D	Punch, axis 5, 3HAB 1524-1
E	Axes 5 and 6, IRB 4400/L10

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5.4. 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.

This is normally handled by the robot calibration software.

Calibration movement directions, 6 axes

Note! The graphic shows an IRB 7600. The positive direction is the same for all 6-axis robots, except the positive direction of axis 3 for IRB 6400R which is in the opposite direction!

xx0200000089

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5.5. Updating revolution counters

General

This section details how to perform a rough calibration of each robot axis, that is updating the revolution counter value for each axis using the pendant.

Step 1 - Manually running the robot to the calibration position

This procedure details the first step when updating the revolution counter, that is, manually running the robot to the calibration position.

	Action	Note
1.	Select axis-by-axis motion mode.	
2.	Jog the robot to place the *calibration marks* within the tolerance zone. IRB 140, 1400, 2400, 4400, 6600ID/ 6650ID, 6640ID: Axes 5 and 6 must be positioned together!	Shown in the section *Calibration scale and correct axis position on page 250*.
3.	When all axes are positioned, store the revolution counter settings.	Described in the section *Step 2 - Storing the revolution counter setting with the TPU on page 254* (RobotWare 4.0). *Step 2 - Storing the revolution counter setting with the FlexPendant on page 256* (RobotWare 5.0).

Step 2 - Storing the revolution counter setting with the TPU

This section details the second step when updating the revolution counter; storing the revolution counter setting with the TPU (RobotWare 4.0).

	Action	Note
1.	Press the button "Miscellaneous" then ENTER to select the service window. xx0100000194	

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	Action	Note
2.	Select `Calibration` from the `View` menu. The Calibration window appears. If there is more than one unit connected to the robot, they will be listed in the window. xx0100000201	
3.	Select the desired unit and choose `Rev Counter Update` from the `Calib` menu. The Revolution Counter Update window appears. xx0100000202	
4.	Select the desired axis and press `Incl` to include it (it will be marked with an x) or press `All` to select all axes.	
5.	Press `OK` when all axes that are to be updated are marked with an x. `CANCEL` returns to the Calibration window.	
6.	Press `OK` again to confirm and start the update. `CANCEL` returns to the Revolution Counter Update window.	
7.	At this point, it is *recommended* that the revolution counter values are saved to a diskette.	Not required.
8.	**CAUTION!** If a revolution counter is incorrectly updated, it will cause incorrect robot positioning, which in turn may cause damage or injury! Check the calibration position very carefully after each update. How to perform the check is detailed in section *Checking the calibration position on page 258*.	

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Step 2 - Storing the revolution counter setting with the FlexPendant

This procedure details the second step when updating the revolution counter; storing the revolution counter setting with the FlexPendant (RobotWare 5.0).

	Action
1.	On the **ABB** menu, tap **Calibration**. All mechanical units connected to the system are shown along with their calibration status.
2.	Tap the mechanical unit in question. A screen is displayed, tap **Rev. Counters**. en0400000771
3.	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.
4.	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**.
5.	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 ticked revolution counters and removes the tick from the list of axes.

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Continued

	Action
6.	**CAUTION!** If a revolution counter is incorrectly updated, it will cause incorrect robot positioning, which in turn may cause damage or injury! Check the calibration position very carefully after each update. See the section *Checking the calibration position on page 258*.

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5.6. Checking the calibration position

General

Check the calibration position before beginning any programming of the robot system. This may be done:

- Using a `MoveAbsJ` instruction with argument zero on all axes.
- Using the **Jogging** window on the FlexPendant.

Using a MoveAbsJ instruction on the TPU, S4Cplus

This section describes how to create a program that runs all the robot axes to their zero position

	Action	Note
1.	Create a new program.	
2.	Use MoveAbsJ.	
3.	Create the following program: `MoveAbsJ [[0,0,0,0,0,0],[9E9,9E9,9E9,9E9,9E9,9E9]]\NoEOffs, v1000, z50, Tool0`	
4.	Run the program in manual mode.	
5.	Check that the calibration marks for the axes align correctly. If they do not, update the revolution counters.	The calibration marks are shown in the section *Calibration scale and correct axis position on page 250*. How to update the revolution counters is detailed in the section *Updating revolution counters on page 254*

Using a MoveAbsJ instruction on the FlexPendant, IRC5

Use this procedure to create a program that runs all the robot axes to their zero 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, z50, Tool0`	
5.	Run the program in manual mode.	
6.	Check that the calibration marks for the axes align correctly. If they do not, update the revolution counters!	The calibration marks are shown in the section *Calibration scale and correct axis position on page 250*. How to update the revolution counters is detailed in section *Updating revolution counters on page 254*.

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Using the Jogging window on the TPU, S4Cplus

This section describes how to jog the robot to all axes zero position.

	Action	Illustration/Note
1.	Open the Jogging window.	xx0100000195
2.	Choose running axes-by-axes.	xx0100000196
3.	Manually run the robot axes to a position where the axis position value read on the TPU, is equal to zero.	
4.	Check that the *calibration marks* for the axes align correctly. If they do not, *update the revolution counters*!	The calibration marks are shown in the section *Calibration scale and correct axis position on page 250*. Detailed in the section *Updating revolution counters on page 254*.

Using the Jogging window on the FlexPendant

This section describes how to jog the robot to all axes zero position.

	Action	Note
1.	Tap **Jogging** in the ABB menu.	
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 calibration marks for the axes align correctly. If they do not, update the revolution counters!	The calibration marks are shown in the section *Calibration scale and correct axis position on page 250*. How to update the counters is detailed in section *Updating revolution counters on page 254*.

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5.7. Additional calibration instruction, IRB4400

Instruction

Before updating the revolution counters (coarse calibration) on IRB 4400, the stainless steel metal ring on axis 4 need to be removed.

Illustration

xx0600003124

A	Upper arm
B	Stainless steel ring
C	Hose clamp

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6 Decommissioning

6.1. Environmental information

Hazardous material

The table specifies some of the materials in the robot and their respective use throughout the product.

Dispose of the 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 (PVC)	Cables, connectors, drive belts, and so on.
Oil, grease	Gearboxes
Aluminium	Covers, sync. brackets

Oil and grease

Where possible, arrange for the 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 may form a film on water surfaces causing damage to organisms. Oxygen transfer could also be impaired.
- Spillage may penetrate the soil causing ground water contamination.

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6.2. 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	-	The content is defined in the section *Standard toolkit on page 275*.
Cutting torch		For opening housing and cutting coils
Other tools and procedures may be required. See references to these procedures in the step-by-step instructions below.		These procedures include references to the tools required.

DANGER!

Do not under any circumstances, deal with the balancing device in any other way than that detailed in the product documentation! For example, attempting to open the balancing device is potentially lethal!

Action on field, decommissioning

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

	Action	Note
1.	Remove the balancing device from the robot.	
2.	Send the device to a decommissioning company.	Make sure the decommissioning company is well informed about the stored energy built up by high tensioned compression springs and that the device contains some grease. The following procedure contains useful information about decommissioning.

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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! The device also contains some grease!	
2.	Place the device on a workbench or similar. Make sure it is clamped in position with a vice or similar.	
3.	Open a hole in the side of the housing as shown in the figure.	Use a cutting torch. The measurements shown below are maximum values!
4.	Cut the coils of the three springs inside the housing as specified below: • Outer spring: cut at least five coils! • Middle spring: cut at least four coils! • Inner spring: cut at least four coils!	Use a cutting torch.
5.	Double-check the number of coils cut and make sure all the tension in the springs is removed.	

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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.

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7.2. Applicable safety standards

Standards, EN ISO

The manipulator system is designed in accordance with the requirements of:

Standard	Description
EN ISO 12100 -1	Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology
EN ISO 12100 -2	Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles
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[1]	Robots for industrial environments - Safety requirements -Part 1 Robot
EN ISO 9787	Manipulating industrial robots, Coordinate systems and motion nomenclatures
EN ISO 9283	Manipulating industrial robots, Performance criteria and related test methods
EN ISO 14644-1[2]	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[3]	Arc welding equipment - Part 1: Welding power sources
EN IEC 60974-10[3]	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)

1. There is a deviation from paragraph 6.2 in that only worst case stop distances and stop times are documented.

2. Only robots with Protection Clean Room.

3. 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

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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
CAN/CSA Z 434-03 (option 429-1)	Industrial Robots and Robot Systems - General Safety Requirements

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7.3. Unit conversion

Converter table

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

Quantity	Units		
Length	1 m	3.28 ft	39.37 in
Weight	1 kg	2.21 lb	
Pressure	1 bar	100 kPa	14.5 psi
Force	1 N	0.738 lbf	
Moment	1 Nm	0.738 lbf-tn	
Volume	1 L	0.264 US gal	

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7.4. Screw joints

General

This section details how to tighten the various types of screw joints on the robot.

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	Art. no.
Molycote 1000 (molybdenum disulphide grease)	11712016-618

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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 tables below. 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.
- 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%**!

The table below specifies the recommended standard tightening torque for *oil-lubricated screws* with *slotted or cross-recess head screws.*

Dimension	Tightening torque (Nm) Class 4.8, oil-lubricated
M2.5	0.25
M3	0.5
M4	1.2
M5	2.5
M6	5.0

The table below specifies the recommended standard tightening torque for *oil-lubricated screws* with *Allen head screws.*

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
M24	725	960	1150

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The table below specifies the recommended standard tightening torque for *Molycote-lubricated screws* with *Allen head screws*.

Dimension	Tightening torque (Nm) Class 10.9, Molycote-lubricated	Tightening torque (Nm) Class 12.9, Molycote-lubricated
M8	28	35
M10	55	70
M12	96	120
M16	235	280
M20		550
M24	790	950

The table below specifies the recommended standard tightening torque for *water and air connectors* when *one* or *both* connectors are made of *brass*.

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

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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 lifting equipment when handling components with a weight exceeding 22 kg. A wide range of lifting tools and devices are available for each manipulator model.

Example

Below is an example of how a weight specification is presented, inside a procedure table:

	Action	Note
	CAUTION! The motor weighs 32 kg! All lifting equipment used must be sized accordingly!	

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7.6. Document references

General

This manual includes references to additional documentation necessary to perform certain procedures. This section specifies the article numbers for the referenced documentation.

Product specification, robot

The product specification includes generic technical data. The specification listed below is the English version.

Document name	Document ID
Product specification	3HAC9117-1 (M2000, M2004)

Product manuals, controller

The product manuals include information about installation and service activities. The table below specifies the article numbers of the product manuals for all controller models. The part number -001 is the English version.

Document name	Document ID
Product manual, S4Cplus M2000	3HAC021333-001
Product manual, S4Cplus M2000A	3HAC022419-001
Product manual, IRC5 M2004	3HAC021313-001

Operating manual

The operating manual contains instructions for daily operation of robot systems. The table below specifies the article numbers of the operating manuals for different robot systems.

Document name	Document ID	Note
User’s guide (S4Cplus)	3HAC7793-1	Contains instructions for daily operation of S4Cplus based robot systems.
Operating manual - IRC5 with FlexPendant	3HAC16590-1	

Calibration manuals

Document name	Document ID	Note
Operating manual - Calibration Pendulum	3HAC16578-1	Enclosed with the Calibration Pendulum tool set
Instructions for Levelmeter calibration (alternative method)	3HAC022907-001	Enclosed with the Levelmeter 2000.
CalibWare Field 5.0 Application Manual	3HAC030421-001	Manual for Absolute Accuracy calibration

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Additional documentation

Document name	Document ID	Note
Operating manual - Service Information System, IRC5	3HAC025709-001	Details the Service Information System of the robot systems M2004.
External axes	3HAC9299-1	S4Cplus based robot system.
Application manual - Additional axes and stand alone controller	3HAC021395-001	IRC5 based robot systems.

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7.7. Standard toolkit

General

All service (repairs, maintenance and installation) procedures contain 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 table below.

This way, the tools required are the sum of the Standard toolkit and any tools listed in the instruction.

Contents, standard toolkit

Qty	Tool
1	Allen key 5-17 mm
1	Socket with ratchet
1	Box spanner set
1	Screwdriver
1	Torx socket no:20, 25, 30
1	Extension bar 100 mm
2	Puller bar
1	KM nut (KM10, KM17)
1	Lifting hoist
1	Cutting pliers
1	Torque wrench 10-470 Nm

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7.8. 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 toolkit on page 275*, and of special tools, listed directly in the instructions and also gathered in this section.

Calibration equipment, Levelmeter (alternative method)

The table below specifies the calibration equipment required when calibrating the robot with the alternative method, Levelmeter Calibration.

Description	Art. no.	Note
Angel bracket	68080011-LP	
Calibration bracket	3HAC13908-9	
Calibration tool ax1	3HAC13908-4	
Levelmeter 2000 kit	6369901-347	Includes one sensor.
Measuring pin	3HAC13908-5	
Sensor fixture	68080011-GM	
Sensor plate	3HAC0392-1	
Sync. adapter	3HAC13908-1	
Turn disk fixture	3HAC68080011-GU	

Calibration equipment, Calibration Pendulum

The table below specifies the calibration equipment needed when calibrating the robot with the Calibration Pendulum method.

Description	Art. no.	Note
Calibration Pendulum toolkit	3HAC15716-1	Complete kit that also includes operating manual.

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7.9. Lifting equipment and lifting instructions

General

Many repair and maintenance activities require different pieces of lifting equipment, which are specified in each procedure.

The use of each piece of lifting equipment is *not* detailed in the activity procedure, but in the instruction delivered with each piece of lifting equipment.

This implies that the instructions delivered with the lifting equipment should be stored for later reference.

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8 Part list

8.1. Introduction

Overview

This section specifies all the replacement articles of the robot. The parts are shown in exploded views or in foldouts, either in this or in a separate chapter.

Specific spare parts are listed separately in a *Spare part list*.

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8.2. Manipulator

Part list, manipulator

See the Foldout 1, 2, 3:1, 3:2, 4 and 5 for location of parts.

Item	Qty	Name	Art.no	Note
1	1	Foot	3HAC 5947-1	
2	1	Gear box axes 1-3	3HAC 5948-1	/45, /60, L/10
2	1	Gear box axes 1-3	3HAC 5949-1	/FS, L/30
2	1	Gear box axes 1-3	3HAC 025482-001	IRB 4450S
3	26	Screw	3HAB 7700-88	M16x80 8.8, Gleitmo 610
4	14	Washer	3HAA 1001-186	
5	1	Motor unit axis 1 (Elmo)	3HAC 5952-1	/45, /60, L/10, /L30
5	1	Motor unit axis 1 (Elmo)	3HAC 9841-1	/FS
5	1	Motor unit axis 1 (Yaskawa)	3HAC 021724-001	/45, /60, /L10 and 4450S
5	1	Motor unit axis 1 (Yaskawa)	3HAC 021725-001	/L30
5	1	Motor unit axis 1 (Yaskawa)	3HAC 021729-001	/FS
6	2	Motor unit axes 2 and 3 (Elmo)	3HAC 5954-1	/45, /60, /L10, /L30, /FS
6	2	Motor unit axes 2 and 3 (Yaskawa)	3HAC 021725-001	/45, /60, /L10, /L30, /FS and 4450S
7	3	O-ring	2152 0431-11	149x4
8	12	Spring washer	2154 2033-10	10.5x23x2.5
9	4	Screw	3HAB 3409-59	M10x70 12.9, Gleitmo
10	8	Screw	3HAB 3409-51	M10x30 12.9, Gleitmo 610
11	1	Lower arm	3HAC 5955-1	/45, /60, L/10, L/30
	1	Lower arm	3HAC 5956-1	FS
11	1	Lower arm, complete	3HAC025476-001	IRB4450S
12	2	Spring washer	3HAB 3640-1	
13	10	Screw	3HAB 3409-85	M16x55 12.9, Gleitmo 610
14	4	Cushion axis 2	3HAB 9237-1	/45, /60, L/10, L/30
15	2	Cushion axis 3	3HAB 3648-1	
16	20	Screw	9ADA 629-56	M6x16 8
18	1	Parallel arm 45 kg	3HAB 8467-1	/45 and IRB 4450S
18	1	Parallel arm 60 kg	3HAB 8466-1	/60, L/30, L/10, FS
19	1	V-ring	3HAB 3732-11	
20	1	Groove ball bearing	3HAB 3710-14	61830
21	1	Sealing ring	3HAB 3749-1	
22	2	Washer	3HAC 7409-1	
23	2	Sealing	3HAB 3701-25	
24	2	Washer	3HAC 4160-1	
25	1	Balancing unit	3HAC 15083-1	/45, /60, L/10, L/30
25	1	Balancing unit	3HAC 15083-2	/FS
25	1	Balancing unit	3HAC025477-001	IRB 4450S

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Continued

Item	Qty	Name	Art.no	Note
26	2	Shaft	3HAC 3970-1	
27	1	Needle roller bearing	3HAB 3757-17	
28	1	Securing plate	3HAC 4168-1	
29	1	Stop pin	3HAB 3647-1	
30	1	Cushion	3HAB 3741-1	
31	1	Screw	9ADA 183-38	M8x30 8.8
32	1	Plain washer	9ADA 312-7	8.4x16x1.6
33	1	Stop screw	9ADA 205-73	M10x12
34	1	Sync. market axis 3	3HAB 3755-1	
35	2	Washer	3HAB 3704-1	
36	4	Screw	2121 2851-449	M8x16 8.8
37	3	Oil 1171 2016-604	3HAC 0575-1	6 litres, ISO VG 320EP./ 45, /60, L/10, L/30,
37	4	Oil 1171 2016-604	3HAC 0575-1	Foundry 6 litres, ISO VG 320EP. FS
37	3	Oil 1171 2016-604	3HAC 0575-1	6.2 litres, ISO VG 320EP IRB 4450S
38		Grease	3HAB 3537-1	200 g
39		Locking liquid	1269 0014-429	1 ml, Loctite 243
40		Sealing ring	3HAB 3701-26	
41	2	V-ring	3HAB 3773-11	
42		Grease	3HAC 2331-1	100 ml
43	4	Bearing sleeve	3HAC 4156-1	6.3 x 2.4
44	1	Cylindrical roller bearing	3HAC 4334-2	
46	1	Screw	9ADA 183-48	M10x16 8.8
47	1	Plain washer	9ADA 312-8	10.5x20x2
48	1	Holder	3HAC 4162-1	
49	2	Bushing	3HAC 3977-1	
50	2	Sealing	3HAC 3297-1	
51	1	Parallel bar	3HAC 1621-1	
52	2	Spher. roller bearing	3HAA 2167-11	
53	2	Sealing without dustlip	3HAC 3990-11	
54	1	Upper arm without wrist and motors	3HAC17542-1	/45, /60 and IRB 4450S
54	1	Upper arm without wrist and motors	3HAB 8281-1	F/45, F/60
54	1	Upper arm without wrist and motors	3HAC 1670-1	L/30
54	1	Upper arm without wrist and motors	3HAC 1629-3	L/10
55	2	Sealing with dustlip	3HAC 7877-1	
56	2	Tapper roller bearing	3HAA 2103-13	
57	2	VK-cover	3HAA 2166-11	80x10
58	2	Lock nut	2126 2851-110	M50x1.5

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Continued

Item	Qty	Name	Art.no	Note
59	2	Shaft end	3HAC 4744-1	
60	1	Sync. market axis 2	3HAB 3754-1	
61	4	Washer	3HAA 2356-13	6.4x22x1.5
63	1	Step protector	3HAC 3943-1	
64	3	Air ventilation plug	3HAC 0127-1	/45, /60, L/10, L/30 and IRB 4450S
64	2	Air ventilation plug	3HAC 0127-1	FS
65	2	V-ring	3HAB 3732-15	
66	2	O-ring	3HAB 3772-23	
67	1	Sealing	3HAC 5479-1	
68	1	Sealing	3HAC 5479-2	
69	1	Rubber protection	3HAC 7823-1	F/45 F/60 FL/30, FS
100	1	Cable unit axis 1-3	3HAC 5958-1	IRB 4400 all models
100	1	Cable unit axis 1-3	3HAC 025479-001	IRB 4450S
101	1	Cable unit axis 4-6	3HAC 8304-1	IRB 4400 all models
101	1	Cable unit axis 4-6	3HAC 025480-001	IRB 4450S
102	1	Bottom plate	3HAC 3692-1	
103	1	Gasket	3HAC 3688-1	
104	1	Cover	3HAC 8306-1	/45 /60 L/10 L/30 and IRB 4450S
104	1	Cover	3HAC 8299-1	F/45 F/60 FL/30, FS
105	1	Gasket	3HAC 3547-1	
106	1	Cable bushing	3HAC 3388-1	
107	1	Bracket	3HAC 4116-1	IRB 4400
107	1	Bracket	3HAC 024049-001	IRB 4450S
108	2	Holder for cable guide	3HAB 3299-1	
109	1	Cable guide	3HAB 3756-1	
110	1	Spring	3HAB 3662-1	
111	1	Cable guide upper arm	3HAB 3699-1	
112	3	Cover	3HAC 2327-1	
113	1	Cover punchb. 4400	3HAC 3585-1	
114	1	Cover	3HAB 3666-1	
116	23	Screw	2121 2416-329	M5x16 8.8
118	20	Nut with flange	9ADA 290-1	M5 fzb
119	30	Straps, outdoor	2166 2055-3	4.8x208
120	22	Bolt with flange	2121 2172-228	M5x12 8.8
121	1	Push button unit	3HAA 0001-ADX	
122	4	Distance bolt	2125 2052-198	M5x15
123	1	Pushbutton guard	3HAC 2744-1	
124	8	Screw	2121 2477-291	M4x12
125	1	Housing 64-p	5217 687-22	/45 /60 L/10 L/30 and IRB 4450S
125	1	Protection cover 64-p	3HAC 7818-1	F/45 F/60 FL/30, FS

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Continued

Item	Qty	Name	Art.no	Note
126	1	Designition sign	3HAB 8431-1	
127	36	Screw	9ADA 629-43	M5x10
128	1	Bracket	3HAC 024590-001	IRB 4450S
130	2	Screw	3HAC 4867-11	M20x90, UNBRAKO 12.9
132	2	Dust cap	3HAC 7561-3	
133	1	Dust cap	3HAC 7561-4	
135	6	Screw	9ADA 183-34	M8x12 8.8
137	34	Screw	9ADA 629-44	M5x12 8
138	15	Cable strap, indoor	2166 2054-1	2.5x101 mm
139	1	Coupling	3HAB 3333-20	
140		Locking liquid	1269 0014-412	1 ml, Loctite 542
141	3	Protective hood	2522 2101-8	D=11.4 - 13
144	2	Spring pin	9ABA 142-62	
147	3	Gasket	3HAB 3675-1	
148	3	Gasket	3HAB 3676-1	
150		Flange sealing	1234 0011-116	1 ml, Loctite 574
152	1	Gasket	3HAB 7097-1	/45 /60 L/10 L/30 and IRB 4450S
153	9	Screw	9ADA 618-46	M5x20 8.8
154	1	Gasket	3HAB 9040-1	/45 /60 L/10 L/30 and IRB 4450S
155	1	Housing 40-p	3HAB 6411-1	/45 /60 L/10 L/30 and IRB 4450S
155	1	Protection cover 40-p	3HAC 7816-1	F/45 F/60 FL/30, FS
A	1	SIM-ring	2522 290-32	196.5x254x15/10 BAB 6 SL NLR
158	4	Cable starps, outdoor	2166 2055-6	Polyamide 6.6, black, 7.6x368
160	1	Counterweight	3HAC 7531-1	FS30
161	4	Hex socket head cap screw	3HAB 3409-50	Steel 12.9 M10x40, Gleitmo 610

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8.3. Upper arm part, axes 4-6

Part list, upper arm part

See the Foldout 6:1, 6:2 and 6:3 for location of parts.

Item	Qty	Name	Art.no	Note
	1	Upper arm without wrist and motors.	3HAC 17542-1	Foundry, but also used for std version
1	12	Hex socket head cap screw	9ADA 183-40	M8x40 8.8-A2F
2	10	Plain washer	9ADA 312-7	8.4x16x1.6 A2F
4	3	Hex socket head cap screw	3HAB 3409-57	M10x60 12.9. Gleitmo 610
5	3	Spring washer	2154 2033-10	10.5x23x2.5 fzm
13	1	Stop axis 4	3HAB 3759-1	
14	1	Damper	3HAB 3760-1	
15	4	Screw	9ADA 183-35	M8x16 8.8
25	8	Screw	3HAB 3409-51	M10x30 12.9. Gleitmo 610
26	8	Plain washer	9ADA 312-8	10.5x20x2 /45, /60, F/45 and IRB 4450S
26	6	Plain washer	9ADA 312-7	8.4x16x1.6 F/60, L10, L/30, FL/30, FS8.
27	1	O-ring	2152 2012-541	199.3x5.7 /45, /60, F/45 and IRB4450S
27	1	O-ring	3HAB 3772-12	126x4 F/60, L/30, FL/30, FS, L/10
28	1	Wrist	3HAB 8271-1	F/45, F/60, FL/30, FS and IRB 4450S
28	1	Wrist	3HAB 9398-1	L/10
29	1	Gear, axis 6	3HAB3613-1	
31	1	Flange sealing	1234 0011-116	1 ml, Loctite 574
33	4	Magnetic plug	2522 122-1	R1/4” /45, /60, F/45, F/60, L/30 and IRB 4450S
33	2	Magnetic plug	2522 122-1	R1/4” FL/30, FS
34	4	Sealing washer	2152 2031-6	13.7x20.6 /45, /60, F/45 and IRB 4450S
34	2	Sealing washer	2152 2031-6	13.7x20.6 F/60, L/30, FL/30, FSL/10
35	4	Lubricating oil	3HAC 0860-1	Axis 4: 3.4 litres Optimol
35	2	Lubricating oil	3HAC 0860-1	Axes 5 and 6: 3.4 litres Optimol. /45, /60, F/45, F/60, L/30, FL/30, FS and IRB 4450S. 0.8 litres Optimol, L/10
48	3	O-ring	2152 2012-426	74.5x3

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Continued

Item	Qty	Name	Art.no	Note
49	1	Motor unit axis 4 with pinion (Elmo)	3HAC 10603-1	/45, /60, /L10, /L30, FS
49	1	Motor unit axis 5 with pinion (Elmo)	3HAC 10603-1	/45, /60, /L30, /FS
49	1	Motor unit axis 4 with pinion (Yaskawa)	3HAC 021726-001	/45, /60, /L30, FS and IRB 4450S
49	1	Motor unit axis 4 with pinion (Yaskawa)	3HAC 021962-001	/L10
49	1	Motor unit axis 5 with pinion (Yaskawa)	3HAC 021726-001	/45, /60, /L30, /FS and IRB 4450S
50	1	Motor unit axis 5 with pinion (Elmo)	3HAC 10605-1	/L10
50	1	Motor unit axis 6 with pinion (Elmo)	3HAC 10604-1	/45, /60, /L30, /FS
50	1	Motor unit axis 6 with pinion (Elmo)	3HAC 10605-1	/L10
50	1	Motor unit axis 5 with pinion (Yaskawa)	3HAC 021962-001	/L10
50	1	Motor unit axis 6 with pinion (Yaskawa)	3HAC 021728-001	/45, /60, /L30, /FS and IRB 4450S
50	1	Motor unit axis 6 with pinion (Yaskawa)	3HAC 021962-001	/L10
51	24	Screw	3HAB 3409-26	M6x25 12.9, Gleitmo 610
52	12	Conical spring washer	2154 2033-7	6.4x14x1.5
52	1	Customer cable extension, axis 4	3HAC 8820-1	Option 04y. See figure below!
56	1	Cover axis 4		
57	6	Hex socket head cap screw	3HAB 3409-38	M8x30 12.9 Gleitmo 610, L/10

Signal cabling, upper arm

xx0300000409

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8.4. Serial measurement unit

Part list, serial measurement unit

See the Foldout 7 for location of parts.

Item	Qty	Name	Art.no.	Note
3	1	Battery pack, new	3HAC 16831-1	Lithium
3	1	Battery pack, old	4944 026-4	NiCd 7.2 V 4 Ah
4	4	Straps, outdoor	2166 2055-6	L=368 mm
5	1	Serial measurement board, new	3HAC 17396-1	DSQC 562 Includes battery 3HAC 16831-1
5	1	Serial measurement board, new	3HAC 16014-1	Does not include battery!
7	1	Serial cable	3HAC7819-1	
8	2	Straps, outdoor	2166 2055-3	L=208 mm
9	1	Label	2940 1413-1	38x19

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8.5. Position switch, axis 1

Part list, position switch

See the Foldout 8 for location of parts.

Item	Qty	Name	Art.no.	Note
	1	Pos. switch ax 1, 1 sw	3HAC 12042-1	Option 25-2 Standard, complete set
	1	Pos. switch ax 1, 1 sw	3HAC 12042-2	Option 25-2 Foundry, complete set
	1	Pos. switch ax 1, 2 sw	3HAC 12054-1	Option 25-4 Standard, complete set
	1	Pos. switch ax 1, 2 sw	3HAC 12054-2	Option 25-4 Foundry, complete set
	1	Pos. switch ax 1, 3 sw	3HAC 12071-1	Option 25-3 Standard, complete set
	1	Pos. switch ax 1, 3 sw	3HAC 12071-2	Option 25-3 Foundry, complete set
	1	Pos. switch cable	3HAC 7997-1	7 m
	1	Pos. switch cable	3HAC 7997-2	15 m
	1	Pos. switch cable	3HAC 7997-3	22 m
	1	Pos. switch cable	3HAC 7997-4	30 m
1	1	Position switch 1	3HAC 8039-1	ax1 pos.sw. (one) option
1	1	Position switch 1-2	3HAC 8040-1	ax1 pos.sw. (two) option
1	1	Position switch 1-3	3HAC 8041-1	ax1 pos.sw. (three) option
2	1	Segment Foundry	3HAC 6474-1	ax1 pos.sw. (one, two, three)
3	3	Cam, blank	3HAC 4476-1	ax1 pos.sw. (one)
3	5	Cam, blank	3HAC 4476-1	ax1 pos.sw. (two)
3	7	Cam, blank	3HAC 4476-1	ax1 pos.sw. (three)
4	1	Bracket Foundry	3HAC 6558-1	ax1 pos.sw. (one, two, three)
5	4	Distance bolt	2125 2052-216	2 1914-04 M6x55 protection (foundry)
5	3	Torx pan head roll. screw	9ADA 629-56	Steel 8-A2F, M4x20, protection (foundry)
6	2	Hex socket head cap screw	9ADA 183-6	Steel 8.8-A2F. M4x20 ax1possw(one)
6	6	Hex socket head cap screw	9ADA 183-6	Steel 8.8-A2F. M4x20 ax1possw(two)
6	4	Hex socket head cap screw	9ADA 183-6	Steel 8.8-A2F. M4x20 ax1possw(three)
7	4	Shims-sheet	3HAB 7478-1	ax1possw(one)
7	8	Shims-sheet	3HAB 7478-1	ax1possw(two)
7	12	Shims-sheet	3HAB 7478-1	ax1possw(three)
9	6	Torx pan head roll. screw	9ADA 618-54	Steel 8.8-A2F, M6x10 ax1possw(one)

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8.5. Position switch, axis 1

Continued

Item	Qty	Name	Art.no.	Note
9	12	Torx pan head roll. screw	9ADA 618-54	Steel 8.8-A2F, M6x10ax1possw(two)
9	18	Torx pan head roll. screw	9ADA 618-54	Steel 8.8-A2F, M6x10ax1possw(three)
10	1	Bracket position switch	3HAC 8057-1	Limit position switch
11	1	Hexagon nut	9ADA 267-5	Steel 8-A2F, M5 ax1possw(one)
11	1	Hexagon nut	9ADA 267-5	Steel 8-A2F, M5ax1possw(two)
11	1	Hexagon nut	9ADA 267-5	Steel 8-A2F, M5ax1possw(three)
12	1	Cable straps, outdoors	2166 2055-3	Polyamide 6.6 black 4.8x208, ax1possw (one, two, three)
15	1	Label	2940 1413-1	B-619, 38x19 mm ax1possw (one, two, three) Text: R1.LS1. Text height 3 mm
17	6	Hex socket counters, head	2121 2852-449	Steel 8.8 Fe/Zn 5c, M8x16, ax1possw (one, two, three)
19	1	Earth symbol	3HAB 5617-1	ax1possw(one, two, three)
20	1	Assembly instruction	3HAC 7821-1	
21	1	Plain washer	9ADA 312-5	Steel-A2F 5.3x10x1 ax1possw(one)
21	2	Plain washer	9ADA 312-5	Steel-A2F 5.3x10x1 ax1possw(two)
21	3	Plain washer	9ADA 312-5	Steel-A2F 5.3x10x1 ax1possw(three)
22	6	Plain washer	3HAB 8389-1	ax1possw(three)
23	2	Torx pan head roll. screw	9ADA 618-59 *	Steel 8.8-A2F, M6x30, ax1possw (one, two, three)
24	1	Box foundry switch	3HAC 6475-1	protection (foundry)
25	4	Torx pan head screw	9ADA 618-55	Steel 8.8-A2F, M6x12 protection (foundry)

* Excisting screws must be exchanged to this longer screws

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9 Foldouts

9.1. Introduction

Definitions

This chapter contains detailed views of the components on the manipulator.

The numbered details are specified with item numbers in the *Part List*.

The foldouts are divided into:

- Foldout 1: Manipulator (part list: *Manipulator on page 280*)
- Foldout 2: Manipulator (part list: *Manipulator on page 280*)
- Foldout 3: Manipulator (part list: *Manipulator on page 280*)
- Foldout 4: Manipulator (part list: *Manipulator on page 280*)
- Foldout 5: Manipulator (part list: *Manipulator on page 280*)
- Foldout 6.1: Upper arm part, axes 4-6 (part list: *Upper arm part, axes 4-6 on page 284*)
- Foldout 6.2: Upper arm part, axes 4-6 (part list: *Upper arm part, axes 4-6 on page 284*)
- Foldout 6.3: Upper arm part, axes 4-6 (part list: *Upper arm part, axes 4-6 on page 284*)
- Foldout 7: Serial measurement unit (part list: *Serial measurement unit on page 286*)
- Foldout 8: Position switch, axis 1 (part list: *Position switch, axis 1 on page 287*)

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9.1. Introduction

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I) Tightening torque 70 Nm
]tdragningsmoment 70 Nm

II) Tightening torque 95 Nm
]tdragningsmoment 95 Nm

III) Tightening torque 60 Nm
]tdragningsmoment 60 Nm

IV) Tightening torque 260 Nm
]tdragningsmoment 260 Nm

V) Tightening torque 82 Nm
]tdragningsmoment 82 Nm

VI) Tightening torque 470 Nm
]tdragningsmoment 470 Nm

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Foldout 2

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Foldout 3:1

IRB 4450S

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L - L

M - M

K - K

N - N

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Foldout 6:1

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FS/30

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10 Circuit diagram

10.1. About circuit diagrams

Overview

The circuit diagrams are not included in this manual but delivered as separate documents on the documentation DVD. See below for correct article numbers.

Controllers

Product	Article numbers for circuit diagrams
IRC5 with Drive System 04	3HAC024480-004
IRC5 with Drive System 09	3HAC024480-005
IRC5 Panel Mounted Controller	3HAC026871-005
IRC5 Compact	3HAC031403-003

Manipulators

Product	Article numbers for circuit diagrams
IRB 120	3HAC031408-003
IRB 140	3HAC6816-3
IRB 260	3HAC025611-001
IRB 360	3HAC028647-009
IRB 660	3HAC025691-001
IRB 1410	3HAC2800-3
IRB 1600	3HAC021351-003
IRB 2400	3HAC6670-3
IRB 2600	3HAC029570-007
IRB 4400/4450S	3HAC9821-1 3HAC9821-1
IRB 4600	3HAC029038-003
IRB 6400RF	3HAC8935-1
IRB 6600 type A	3HAC025744-001
IRB 6600 type B	3HAC025744-001
IRB 6620	3HAC025090-001
IRB 6620LX	3HAC025090-001
IRB 6640	3HAC025744-001
IRB 6650S	3HAC025744-001
IRB 6660	3HAC029940-001 (DressPack) 3HAC025744-001
IRB 7600	3HAC025744-001

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A

Absolute Accuracy, calibration 249

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