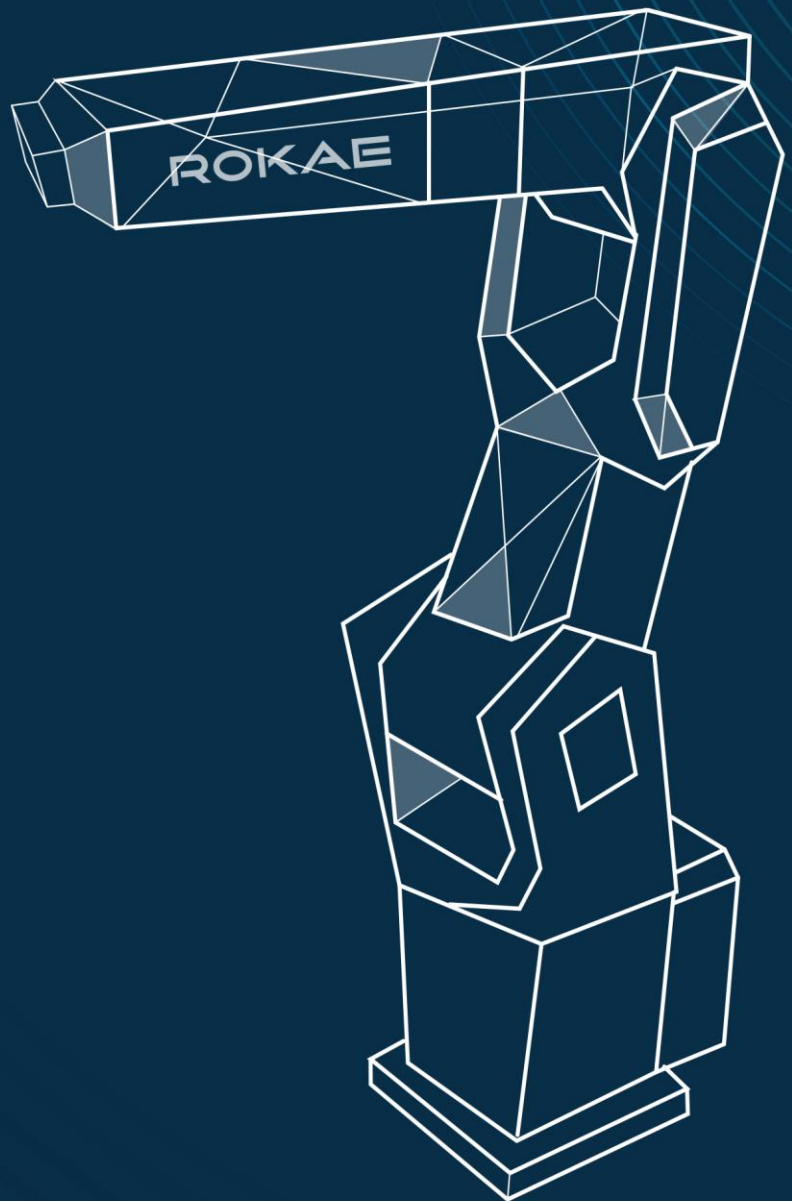


ROKAE

NB220 Series Product Manual



More intelligent, more efficient

NB220 Series

Product Manual

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Version: A

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ROKAE has proofread the contents of this manual. However, the possibility of errors or inconsistencies cannot be ruled out, and ROKAE shall not be held liable for any errors or inconsistencies.

This manual is subject to update without prior notice.

We cannot foresee all possible dangers and consequences. Therefore, this manual cannot warn the user of all possible hazards.

If you find the contents of this manual wrong or in need of improvement or supplement, please contact us for correction.

This manual is originally written in Simplified Chinese. Other language versions are translated.

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1 Manual Overview

1.1 About this manual

Thank you for purchasing our robot system.

This manual contains the following instructions for correct installation and use of the robot:

- Mechanical and electrical installation of the robot
- Maintenance and calibration of the robot

Please read this manual and other related manuals carefully before installing and using the robot system.

After reading, keep the manual properly so that you can read it at any time.

1.2 Target group

This manual is for:

- Installation personnel
- Maintenance personnel

Please ensure that the above personnel have the necessary knowledge of mechanical and electrical installation and maintenance, and have received our relevant training.

1.3 How to read the product manual

This manual includes a separate safety chapter that must be read through before proceeding with installation or maintenance operations.

1.4 Illustrations in this manual

Due to product upgrades or other reasons, some figures in the product manual may differ from the actual product. However, the operating procedures are correct.

Also, figures of other types of robots may be used to describe some general information.

1.5 Contact

For matters related to maintenance and repair of the robot, please contact our after-sales department or the local reseller.

Service hotline: 400-010-8700.

Get the following information ready when contacting us:

- Controller model/serial number
- Robot model/serial number
- Software name/version
- Problems with the system

2 Safety

2.1 Introduction

This section describes the safety principles and processes that need to be noted when using the robot.

The contents related to the design and installation of the external safety protection device of the robot are not covered within this section. Please contact your system integrator to obtain such information.

2.1.1 Safety responsibility description

ROKAE is dedicated to but not liable for providing reliable safety information. Even if all operations are carried out according to the safe operation instructions, we cannot guarantee that our industrial robots will not cause personal and property losses.

In addition to the safety section, please also note that there are other safety reminders in the necessary parts of the document.

2.1.2 Using the robot in compliance

The industrial robots should be used in accordance with local laws and regulations, and must not be used for any purpose that violates such laws and regulations.

Using the robot in compliance also means observing the instructions in product manuals of various individual components, including the operation, installation and maintenance instructions for them.

The following uses that violate the rules shall be prohibited:

- Transporting people and animals
- Using in environments with explosion hazard
- Using in flammable environments
- Using outside the permissible range
- Using downhole

2.2 Safety terms





2.2.1 Safety symbols

2.2.1.1 About safety symbols

There may be different degrees of danger when operating the robot in accordance with this manual, so there will be a special safety symbol in the vicinity of dangerous operation instructions to remind the user to be careful. The contents include:









- An icon that indicates safety level and the corresponding name, such as warning, danger, tips, etc.;
- A brief description given to illustrate the possible consequences if the operator does not eliminate the danger;
- Operating instructions on how to eliminate dangers.


2.2.1.2 Safety levels

Icon	Name	Description
	Danger	For those coming with this sign, failure of following the rules in operation may cause serious or even fatal injury to personnel, and will/may cause serious damage to the robot. Operations related to such hazards include contacting high-voltage devices in the control cabinet, entering the working area when the robot is running, etc.
	Warning	For those coming with this sign, failure of following the rules in operation may cause serious and even fatal personal injury, and will cause a great damage to the robot.
	Alert	For those coming with this sign, failure of following the rules in operation may cause personal injury, and may cause damage to the robot.
	Tips	This icon indicates important information or prerequisites.

2.2.2 Hazard description

2.2.2.1 Hazards

Icon	Name	Description
	Squeezing	There may be an injury to the operators and maintenance personnel who enter into the motion range of the robot during debugging, repair, overhaul and tool installation.
	Hand pinching	There may be a risk of hand pinching when the maintenance personnel approach the belt drive parts or other moving parts during maintenance.
	Strike	There may be a serious injury to the operators and maintenance personnel who enter into the motion range of the robot during debugging, repair, overhaul and tool installation.
	Friction	There may be an injury to the operators and maintenance personnel who enter into the motion range of the robot during debugging, repair, overhaul and tool installation.
	Parts flying out	There may be a serious injury to the operators and maintenance personnel who enter into the motion range of the robot during debugging, repair, overhaul and tool installation when tools or workpieces fly out due to loose clamping.
	Fire	There may be a serious injury due to fire that might occur in case of electrical short circuit or the wire or device on fire.
	Hot surface	During the maintenance and repair of the equipment, a burn may be caused if the maintenance personnel touch the robot's hot surface.
	Electric shock	The current operation may cause an electric shock with a serious or even fatal injury.

Icon	Name	Description
	ESD	The components involved in the current operation are sensitive to static electricity. Failure to operate according to specifications may cause component damage.

**Warning**

Any robot in motion is a potentially fatal machine!

When the robot is running, it may execute undesirable or even unreasonable motions. In addition, the robot carries huge energy when it is running. It will cause serious damage/injury to the personnel and equipment in its working area in case of collision.

2.2.2.2 Danger elimination

	Operation	Reference information
1	Before running the robot, make sure that all safety protection devices have been properly configured and installed.	Safety protection devices include the emergency stop button, safety gate, safety grating, etc.
2	In the process of robot programming, the personnel who enter the robot working area must hold the Teach Pendant.	Personnel outside the working area must avoid using the Teach Pendant to operate the robot without observing the personnel inside the working area.
3	Before starting the robot program, make sure that there are not any person in the robot working area.	
4	When programming the robot's motion, make sure to identify potential collision risks before the first commissioning.	

2.2.3 Safety features**2.2.3.1 Description**

This robot system is equipped with a special safety controller for handling safety-related signals, and provides external safety symbol interfaces such as the safety gate and emergency stop button.

Signals processed or outputted by the safety controller include:

- Emergency stop button signal
- Safety gate signal
- Enabling switch signal
- Mode selection signal
- Emergency stop status signal

2.2.3.2 Applicable safety standards

The robot system is designed in accordance with the following relevant standards:

Standard	Description
2006/42/EC	Machinery directive
2014/30/EU	Electromagnetic compatibility directive
EN ISO 12100:2010	Safety of machinery - General principles for design - Risk assessment and risk reduction

Standard	Description
EN ISO 10218-1:2011	Industrial robots – Safety requirements Part 1: Robots
EN ISO 13849-1:2015	Safety of machinery - Safety-related parts of control systems – Part 1: General principles for design
IEC 60204-1:2016	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems
IEC 62061:2010	Safety of machinery - Functional safety of safety-related electrical/electronic/programmable electronic control systems
IEC 61000-6-2:2016	Electromagnetic compatibility - Generic standards - Immunity standard for industrial environments
IEC 61000-6-4:2011	Electromagnetic compatibility - Generic standards - Emission standard for industrial environments

2.2.4 Motion enabling and safe stop

2.2.4.1 Motion enabling

The motion control function of the robot control system should be enabled by the safety controller, which, when determining the safety level of the current environment through internal logic, controls on/off of drive STO (Safe Torque Off) via safety output signal. Manual operation of the robot by the user and automatic running of the program are not allowed by the control system before the safety controller determines that it is safe at the moment.

2.2.4.2 Safe stop

There are three ways to stop the robot, i.e. STOP 0, STOP 1 and STOP 2.

Safe stop refers to stop triggered by the safety controller, which only involves STOP 0 and STOP 1, while STOP 2 can only be triggered by the control system.

●STOP 0

As the stop method of the highest safety level, STOP 0 cuts off the power source of the motors and engages the band-type brakes of individual joints immediately. During the stopping process, however, the robot is uncontrolled and may deviate from the programmed path after it is stopped.

Safe stop in manual mode is STOP 0. Safe stop caused by operating mode switchover in automatic mode is also STOP 0.

●STOP 1

Once STOP 1 is triggered, the control system immediately executes the deceleration process along the programmed path. Thereafter, whether or not the robot comes to a complete stop, the safety controller will always cut off the power source of the motors and engage the band-type brakes of all joints. Since the stop is controlled, in most cases, the robot will finally stop on the programmed path. Therefore, This emergency stop method provides the best protection for nearby equipment.

Both safe stops arising from the opening of safety gate/safety grating in automatic mode and pressing of the emergency stop button in automatic mode are STOP 1.

●STOP 2

Once STOP 2 is triggered, the control system immediately executes deceleration along the programmed path until the robot stops completely. The power source of the motors is maintained and the band-type brakes are still disengaged, while the robot stays in the current position.

2.2.4.3 Emergency stop

As one of the safe stops, emergency stop is the function of the highest priority in the robot system. Pressing the emergency stop button triggers the emergency stop function. All other robot control functions will stop, the robot will stop movement, the power source of the motors of all joints will be cut off, and the control system will switch to the emergency stop state. Such state will be maintained until reset.

The emergency stop state means that, except the manual band-type brake release circuit, all other power supplies to the robot arm body will be cut off and the reset operation must be executed to restore the system to its normal condition.

**Tips**

Emergency stop is only used to stop the robot immediately in case of danger and cannot be used as a normal program; otherwise, extra and unnecessary abrasion will be caused to the band-type brake system and drive system of the robot to reduce the service life of the robot.

2.2.5 Safety devices

2.2.5.1 Emergency stop button

Most emergency stop buttons are in red. The most common shape is a mushroom. In general, a yellow substrate, protective casing or warning sign is also attached to the emergency stop button. The emergency stop button is mechanically locked when it is pressed. This is the safety lock mechanism for the button. The device must be reset through manual release. Most emergency stop buttons are released by rotation and the direction of rotation is indicated on the button surface. Some buttons also support releasing by upward pulling.

2.2.5.2 Enabling switch

The enabling device is a special switch with two pressing modes and three positions, which is also called three-position enabling switch (hereinafter referred to as "enabling switch"), and is used to control on/off of the power supply of the robot in manual mode, thus realizing motion enabling of the robot.

The enabling switch is installed on the back of the Teach Pendant, as shown in Fig. 1. The motor power supply is switched on only when the enabling switch is pressed and kept in the middle position, so that the robot is allowed to move, and you can perform Jog or run programs. Either releasing or pressing all the way down will cut off the motor power supply.

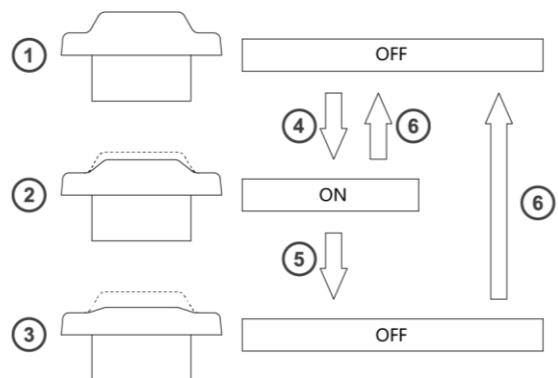


Fig. 1 Enabling switch

No.	Description
1	Position 1
2	Position 2
3	Position 3
4	Lightly press
5	Heavily press
6	Release



Warning

It is strictly prohibited to use any external devices to keep the enabling switch locked or stopped in the middle position!



Tips

Under any circumstances, ensure that the enabling switch can work properly.
During programming and debugging, the enabling switch should be released as soon as possible when robot motion is not required.

2.3 Safety precautions

2.3.1 Overview

2.3.1.1 About the robot

Regardless of the motion velocity, industrial robots pose great potential hazard. A quick and dangerous motion command may be performed following a pause or waiting during program running. Even if you know the motion trajectory and mode of the current robot, the motion trajectory of the robot in auto mode may still be changed by external signals without warning. Therefore, one must observe the safety specifications when entering the working range of the robot.

2.3.1.2 About this section

This section will describe some basic safety specifications to the end users of the robot.

However, it cannot cover each specific circumstance due to limited space.

2.3.2 About the user's own safety

2.3.2.1 Basic principles

To ensure safety when using the robot, the following principles must be observed strictly:

- The personnel are only allowed to operate the robot in manual mode when they are within the safety zone of the robot.
- You should hold the Teach Pendant in your hands when entering the safety zone of the robot to ensure that the robot is under your control.
- Pay attention to the active tools installed on the robot, such as the electric drill and electric saw. Make sure that all these tools have stopped running before you approach the robot.
- Pay attention to the workpiece surface or the robot arm body. The motor and casing temperature of the robot may become very high after prolonged work.
- Pay attention to the gripper of the robot and the objects gripped. If the gripper is opened, the workpiece may fall off and cause personal injury or equipment damage. Moreover, the gripper used on the robot may be very powerful and may cause injury if it is not used according to the specification;
- Pay attention to the electrical components in the robot control cabinet. Even if the power supply has been switched off, the remaining power in the component is still very dangerous.

2.3.3 Safety precautions for operating the Teach Pendant

2.3.3.1 Safe storage of the Teach Pendant

The Teach Pendant no longer used should be removed from the control cabinet and properly stored in a place that is far away from the robot workstation or control cabinet, so as to prevent the operator from mistakenly believing that this Teach Pendant is still connected to the control cabinet and attempting to use it to stop the robot in case of danger.

2.3.3.2 Teach Pendant cable

The Teach Pendant and control cabinet are connected through a Teach Pendant cable. Please comply with the following requirements when using the Teach Pendant in order to avoid personal injury or equipment damage:

- Make sure that the personnel do not stumble over the Teach Pendant cable so as to avoid falling of the Teach Pendant or personnel.
- Do not squeeze the Teach Pendant cable, otherwise, its internal cores may be damaged.
- Do not put the Teach Pendant cable on the edge of sharp objects, otherwise, the cable sheath may be damaged.
- Make sure that the bending radius of the Teach Pendant cable is greater than 100mm, otherwise, the cable may be damaged.

2.3.3.3 Permission of using the Teach Pendant

The mode selection switch of a standard Teach Pendant is equipped with a key, i.e. switchover between manual/auto modes is only possible using the key. Please keep the key properly and

carefully consider the user permission of the key. Generally, only those personnel who have completed safety training and basic operation training can have the permission to use the key.



Warning

The key to the mode selection switch on the Teach Pendant is designed for all Teach Pendants of the same model according to standard.

Ensure that all keys are kept by qualified personnel to prevent misuse.

The user permissions for operating the Teach Pendant interface should also be distinguished to ensure that the debugging personnel and maintenance personnel can use the Teach Pendant correctly and reasonably according to their work.

Three user levels are built into the control system, namely operator, admin and god. The operation permissions rank from low to high. A password must be entered when a user with lower permission level wants to switch to a higher one; but not vice versa. A user of higher level can modify the password of a same- or lower-level user. You cannot modify the password of an operator. For the operation contents of different permission levels, refer to the corresponding control system operation manual.

2.3.3.4 No Teach Pendant mode

When the No Teach Pendant mode is selected for the control system, special attention must be paid to safety during debugging and programming. An emergency stop button device must be installed or placed within the reach of the operator and the signal of the emergency stop button must be routed into the safe IO interface of the robot system so that the person can protect the safety of himself/herself and the equipment by pressing the emergency stop button promptly in case of emergencies.

2.3.4 Safety precautions for using the control cabinet

2.3.4.1 Make sure that there is no conductive foreign objects in the control cabinet

After operations such as repair and component replacement on the control cabinet, make sure to check if there is any conductive foreign object in the cabinet. Such objects may cause short circuit in the control cabinet during use of the robot, thus resulting in other dangers.

2.3.4.2 Do not supply power to the control cabinet when the cabinet door is open

- Make sure that the cabinet door has been closed before switching on the robot control cabinet.
- Not all electrical devices or nodes in the control cabinet are protected. Therefore, do not use the control cabinet when the cabinet door is open to avoid fatal danger to the operator or equipment!
- The control cabinet cannot reach the claimed protection level when the cabinet door is open.
- When the cabinet door is open, components in the cabinet are more prone to electromagnetic interference and may generate excessive radiation to the outside, thus directly affecting the use of the robot system.

2.3.4.3 Do not use the control cabinet for other purposes

The control cabinet is only used to control motion of the robot arm body. Using it for any other purposes, such as standing on the cabinet body, working on the control cabinet and using the

cabinet body as a ladder, is prohibited.

2.3.5 Emergency stop button test

The emergency stop button is the only means to trigger the emergency stop as well as the most important device to protect the safety of operators and equipment in case of emergency. Therefore, when the robot is put into use for the first time and when the robot is started for the first time after an overhaul, you must first test the emergency stop button, including testing the external emergency stop button that the integrator has connected into the robot system, so as to confirm that pressing the emergency stop button can force the equipment to enter the emergency stop state and executing the reset operation can exit the emergency stop state. Only after confirming the normal operation of the emergency stop button can you conduct configuration or programming on the robot.

2.3.6 Resetting the emergency stop

2.3.6.1 Description

When the system is in the emergency stop state, reset it to return to its normal state. The reset process is simple but very important. It ensures that the robot system will not be put into production and operation in a dangerous state.

2.3.6.2 Resetting the emergency stop button

All button-shaped emergency stop devices are equipped with a safety lock mechanism, which must be released manually after being pressed to reset the emergency stop. Most emergency stop buttons are released by rotation and the direction of rotation is indicated on the button surface. Some buttons also support releasing by upward pulling.

2.3.6.3 Operating procedures of resetting the emergency stop

NO.	Operation
1	Confirm that the dangerous conditions causing emergency stop have been handled properly and the danger is removed.
2	Reset the safety device causing emergency stop.
3	Press the reset button on the control cabinet or click the reset button on the Teach Pendant/PC interface to recover the system from the emergency stop state. In auto mode, you can also use the system input signal to reset the system emergency stop state. Caution! This operation depends on the control cabinet model. For specific operations, refer to the corresponding control cabinet product manual and control system operation manual.

2.3.7 Band-type brake test

When the system enters the emergency stop state, the power source of the motors will be cut off and the band-type brakes of all joints will engage. Therefore, the normal operation of the band-type brakes helps ensure the safety of the operator and reduces risks when the robot enters the emergency stop state.

During daily use of the robot, normal wear will occur to the band-type brakes of individual joints. It is very necessary to carry out band-type brake tests to ensure its functioning.

The testing method is as follows:

NO.	Operation
-----	-----------

1	In manual mode, run each axis to its maximum load position.
2	Press the enabling switch and keep it in the middle position. Then the motor power supply is switched on and the band-type brakes are disengaged.
3	Release the enabling switch to engage the band-type brakes. Observe if the robot arm body keeps its previous position. You can observe the angle value of each axis through the Teach Pendant to confirm that the position of each joint remains unchanged.
4	Test each axis one by one. If the position of each axis remains unchanged, it is believed that the band-type brake function works well.

2.3.8 Manual release of the band-type brake

When the robot is in the emergency stop state, all other power supplies to the robot arm body are cut off except the manual band-type brake release circuit. In case of emergency, you can move the robot arm body by manually releasing the band-type brake.

A band-type brake release button is installed on the standard control cabinet. When this function is not used, keep the protective cover of this button in place so as to prevent this function from being triggered mistakenly.

The band-type brake release button is also installed on some models of robot arm bodies. The method for triggering this function is different based on the models. Please carefully check the product manual of the corresponding arm body.



Danger

Before manually releasing the band-type brake, make sure that the trapped person and operator will not be injured during the process of moving the arm body!



Warning

When moving the robot arm body by manually releasing the band-type brake, please note:

For small-load models, you can manually move each axis of the arm body. For medium- and large-load models, a traveling crane, a hoist or other equipment should be used to help move each axis of the arm body.

2.3.9 Safety precautions in manual mode

2.3.9.1 About manual mode

In manual mode, the motion of the robot is under manual control. Only when the enabling switch is in the middle position can you perform Jog or run programs on the robot.

The manual mode is used to write and debug robot programs and engage in commissioning of the workstation.

2.3.9.2 Speed limitation in manual mode

The motion velocity of the robot end is limited to less than 250mm/s in manual mode. This means that the maximum motion velocity of the robot end will not exceed 250mm/s whether you perform Jog or run programs on the robot, regardless of the set velocity in the program.

2.3.9.3 Bypass external safety signals

In manual mode, signals of external safety devices such as the safety door and safety grating will be bypassed, i.e. in manual mode, the system can still perform motor enabling operations even if the safety door is opened. The system will not prompt the safety door opening information for the convenience of debugging.

2.3.10 Safety precautions in auto mode

2.3.10.1 About auto mode

The auto mode is used to run robot programs during the formal production process. In auto mode, the enabling switch will be bypassed, so that the robot can be operated automatically without personnel involved.

2.3.10.2 Enabling external safety signals

In auto mode, external safety devices such as the safety door and safety grating will be enabled. When the safety door is opened, the motor power supply will be switched off and the band-type brake will be engaged.

2.3.11 Safe handling on the production line

In most cases, the robot is a part of the production line. Therefore, robot failures do not only affect the robot itself, but may also affect the entire production line. Likewise, problems with other parts of the production line may also affect the robot. For this reason, a fault remedial plan should be designed by personnel who are very familiar with the entire production line in order to improve the safety of the whole system.

- Pay attention to other devices that interact with the robot

For example, when a robot needs maintenance, you must first remove it from the production line, as well as remove other devices interacting with the robot, such as the robot loading it.

- Pay attention to other running devices around the robot

For example, a robot on the production line grabs workpieces from the conveyor belt. When the robot fails and in order to guarantee uninterrupted production, the conveyor belt may keep running while the robot is being repaired. The robot maintenance personnel must pay extra attention to safety, give advance consideration to the risks that might arise from the running conveyor belt and develop detailed safety measures for working in such environment.

2.3.12 Safe handling of fire accidents

2.3.12.1 Measures against mild fire

Do not panic and stay calm in case that the fire is expected or has happened but yet to spread; you can use on-site fire-extinguishing equipment to put out the flame. Do not use water to put off fires caused by short circuit.



Warning

The fire-extinguishing equipment on the working site of the robot shall be supplied by the user. The user shall choose appropriate fire-extinguishing equipment according to the actual situations of the site. For fire with the controller, use a carbon dioxide (CO₂) fire extinguisher.

2.3.12.2 Measures against severe fire

When the fire has spread and become out of control, the personnel on site should immediately notify other personnel to give up their personal belongings and evacuate from the emergency exit as soon as possible rather than trying to put out the fire. Do not use the elevator during evacuation and call the fire brigade during evacuation.

If the clothes catch fire, do not run but quickly lie flat on the ground, and put out the fire using clothes or other appropriate items or methods.

2.3.13 Safe handling of electric shock accidents

2.3.13.1 Measures against electric shocks

When someone gets an electric shock, do not panic but cut off the power supply as soon as possible. Appropriate methods and measures should be adopted without hesitation according to the site conditions:

- If the power switch or button is near to the location of the electric shock, switch it off at once to cut off the power supply.
- If the power switch or button is far away from the location of the electric shock, you can use insulated pliers or an axe, knife and shovel with dry wooden handle to cut off the live wire on the power side (where the electricity comes from) and keep the cut wire away from the human body.
- If the conducting wire lies on or under the body of the victim, you can use a dry stick, board, bamboo pole or other tools with insulated handles (to hold) to remove the wire quickly. Do not use a metal bar or wet object to remove the wire lest the rescuer gets an electric shock.



Warning

The rescuer should not be in direct contact with the person getting an electric shock, otherwise, the rescuer may also get an electric shock!

2.3.13.2 Treatment of the wounded personnel after removing the power source

- If the wounded is conscious, he/she should lie on the back and be closely observed. The wounded should not stand or walk around.
- If the wounded is unconscious, make him/her lie on the back to keep the airways open. Call the wounded or pat him/her on the shoulder at an interval of 5 seconds to judge if he/she loses consciousness. Do not call the wounded by shaking his/her head. Meanwhile, contact the hospital as soon as possible.
- If the wounded loses consciousness, judge his/her respiratory conditions and heartbeat within 10 seconds. If neither breath nor arterial pulse is sensed, the wounded is deemed with a cardiac arrest. Give first aid immediately by cardiopulmonary resuscitation.

2.4 Personnel and work content requirements

2.4.1 Definition of personnel

There are three types of personnel:

- Operating personnel

The operating personnel can switch on/off the robot power supply and start robot programs through the Teach Pendant or other interfaces, but may not enter into the safety zone.

- Debugging personnel

The debugging personnel can conduct robot operations, enter into the safety zone and perform operations such as setting, teaching and programming on the robot.

- Maintenance personnel

The maintenance personnel can conduct robot operations, enter into the safety zone, perform operations such as setting and teaching on the robot, as well as adjust and repair the robot.



Warning

The debugging and maintenance personnel who can enter into the safety zone must accept and pass professional robot training in advance.



Warning

When performing robot operation, programming and maintenance, the personnel must pay attention to safety and should wear necessary equipment according to the actual conditions, including work clothes, safety shoes and safety helmets suitable for the work contents.

2.4.2 Personnel requirements

2.4.2.1 Operating personnel requirements

The operating personnel should meet the following conditions:

- The age of the operating personnel should fall within the age range of local employment laws.
- The operating personnel should be in a good physical condition. A good physical condition means: good vision (glasses and contact lenses are allowed), good hearing and good coordination ability. The operating personnel may not take items that may reduce mental level (such as medicines, alcohol and drugs) during work.
- The operating personnel should understand applicable local safety regulations, such as the work safety and health regulations and the industrial accident prevention regulations.

2.4.2.2 Debugging personnel requirements

The debugging personnel should meet the criteria of operating personnel. In addition, the debugging personnel should also meet the following conditions:

- The debugging personnel should have basic technical knowledge, understand the technical documents and drawings related to the robot and be able to complete their tasks according to manual documents.
- The debugging personnel must be very familiar with the use of the robot system and be able to reasonably achieve the purpose by operating the robot according to actual needs.

2.4.2.3 Maintenance personnel requirements

The maintenance personnel should meet the criteria of operating personnel. In addition, the maintenance personnel should also have a certain level of other expertises (such as electrical, mechanical and pneumatic) and can complete their tasks according to manual documents.

2.4.3 Work content requirements

2.4.3.1 Safety requirements for installation and operation

- Handling and installation of the robot equipment must be carried out according to the methods described in our manual. Otherwise, the robot may fall due to misoperation, thus leading to personal injury and death or equipment damage.
- When the robot equipment is put into use for the first time after installation, make sure to run it at low velocity first and then gradually increase the velocity rather than running at high velocity from the start.
- By default, program and system variable information is stored in the control cabinet storage device. In order to prevent data loss caused by accidents, it is recommended that the user makes data backup regularly.

2.4.3.2 Safety requirements for debugging

Debugging should be carried out outside the safety zone as much as possible. When debugging must be carried out inside the safety zone, special attention should be given to the following issues:

- Carefully check the situation inside the safety zone and enter into it only after confirming no danger exists.
- Confirm the positions of all debugging personnel inside the safety zone.
- Confirm the status of the entire system before proceeding with the work.
- Make sure that the emergency stop button can be pressed whenever necessary.
- Run the robot at low velocity.

When debugging is finished, the debugging personnel must stay outside the safety zone.

2.4.3.3 Safety requirements for maintenance

- Carefully check the situation inside the safety zone and enter into it only after confirming no danger exists.
- Confirm the positions of all maintenance personnel inside the safety zone.
- When the power supply is switched on, some maintenance operations may pose the danger of electric shock. Switch off the power supply of the robot equipment and system before carrying out the maintenance.
- During the maintenance, prevent other personnel from switching on the power supply accidentally.
- To avoid unnecessary personal injury or adverse impact on the equipment, do not place any part of your body on any part of the robot equipment during the operation.
- Appropriate lighting should be provided during the maintenance.
- In case of part replacement, make sure to use a part specified by ROKAE. Otherwise, the robot equipment may be damaged.
- Parts removed during the replacement (such as screws) should be correctly installed back to their original positions. If you find the parts not enough or redundant, confirm again and make sure to install them correctly.

2.5 Safety training

2.5.1 Overview

The on-site operating personnel, debugging personnel and maintenance personnel must accept formal robot safety and operation training and pass the exams before they can

perform operation, debugging and maintenance on the robot. Operating, debugging or maintaining robots by non-professional personnel or personnel failed during the training is prohibited in order to avoid severe personal injury and damage to the robot equipment.

All the personnel of the equipment should:

- Judge the current condition of the equipment and ensure that no failure is present before performing operation and debugging on the robot equipment.
- Minimize life and property losses by choosing the safest method to handle emergency incidents as they occur.
- Fully understand our product manual documents and work on the equipment according to the requirements of documents.

2.5.2 Personnel safety

Consider the following general precautions to ensure personnel safety:

- When the equipment is running, even if the robot seems to have stopped, it may be waiting for the start signal to run. In this state, the equipment should also be deemed as in the operational state.
- All peripheral equipment should be well grounded.
- Peripheral equipment should be installed outside the working range of the robot as much as possible.
- The motion range of the robot equipment should be marked, e.g. by drawing lines on the floor.

2.5.2.1 Safety of operating personnel

The operating personnel may not enter the safety zone:

- Operate the robot outside the safety zone.
- A protective fence or safety door should be set up in order to prevent irrelevant personnel from entering the safety zone.
- Switch off the control cabinet power supply or press the emergency stop button when not operating the robot.
- The emergency stop button should be set up within reach of the operating personnel.

2.5.2.2 Safety of debugging personnel

During the debugging, you need to enter into the working range of the robot under some circumstances. Special attention must be paid to safety:

- Make sure that the equipment is safe before the debugging.
- Check the position and status of the safety devices (such as the emergency stop button) in advance.
- Take caution not to allow other personnel to enter into the working range of the robot.
- Before starting the robot, make sure that there are no personnel in the working range of the robot.

When the debugging is finished, execute a test run according to the following procedures:

- At low velocity, execute the program one step after another for at least one cycle to confirm that everything is normal.

- At low velocity, execute the program continuously for at least one cycle to confirm that everything is normal.
- At the running velocity of actual application, execute the program continuously for at least one cycle to confirm that everything is normal.

2.5.2.3 Safety of maintenance personnel

The following precautions should be fully noted in order to ensure the safety of the maintenance personnel:

- Make sure that the peripheral equipment is safe before the maintenance.
- Switch off the equipment power supply as much as possible before the maintenance. Lock the main circuit breaker using a lock as necessary in order to prevent other personnel from switching on the power supply accidentally.
- When you have to enter into the working range of the robot while the power is on, press the emergency stop button before entering. The maintenance personnel should put up an "under repair" sign in order to prevent other personnel from operating the equipment accidentally.
- Never enter into the working range of the robot while it is moving.
- Never execute automatic running of the program when there are other personnel within the working range of the robot.
- During the maintenance, a person who is familiar with the robot system and is able to sense dangers should be present near the equipment so that he/she can press the emergency stop button in case of emergency.
- During component replacement or reassembly, be careful to avoid adhesion or inclusion of foreign objects.
- When servicing the interior of the control cabinet, if it is necessary to touch the power supply unit or printed circuit board, make sure to switch off the power supply of the main circuit breaker of the control cabinet first to prevent electric shock.

3 Product Overview

3.1 Introduction

The NB220 series industrial robots prioritize high-takt-time production with compromising payload, basic performance, and stability comparable to other robots in the same class. Robots with different reach and payloads can be produced based on this platform. Currently, three 6-joint models are available: NB220-220/2.7, NB220-170/2.7, NB220-150/3.2.

3.2 Robot

3.2.1 Overview

The basic configuration of the NB220 robot series:

Product name	Wrist payload	Reach	Weight
NB220-220/2.7	220kg	6	Approx. 1138kg
NB220-170/2.7	170kg	6	Approx. 1138kg
NB220-150/3.2	150kg	6	Approx. 1165kg

3.2.2 Robot system

A complete robot system consists of the robot arm body, a control cabinet, a Teach Pendant, a connecting cable, control system software, etc. For details, see Fig. 2.

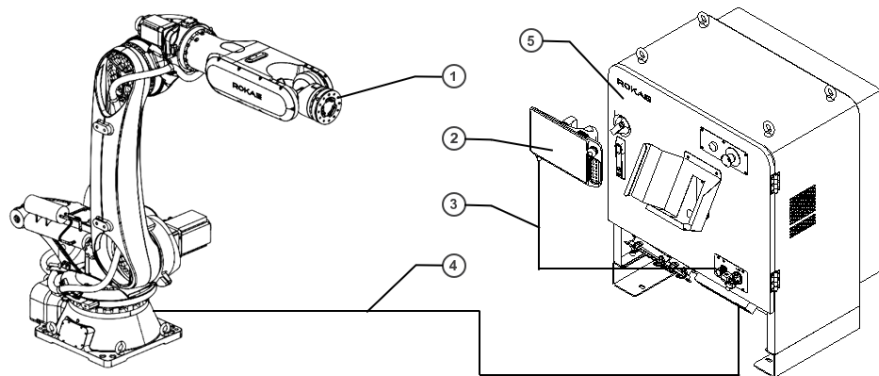


Fig. 2 Robot system

No.	Name
1	Robot body
2	Teach Pendant
3	Teach Pendant cable
4	Cabinet cable
5	Controller

3.2.3 Robot arm body

Among the NB220 series, each type of robot has 6 DOF. The number of DOF is equal to the

number of axes and joints. Each joint motor is equipped with a brake.

The robot body consists of the following parts:

Wrist - The wrist has three degrees of freedom and is located at the output end of the robot, including Axes 4, 5 and 6.

Upper arm - The upper arm is located between the lower arm and the wrist joint, driven by the Axis 3 motor.

Lower arm - The lower arm is located between the upper arm and the swing joint, driven by the Axis 2 motor.

Swing joint- The swing joint is located between the lower arm and the base, driven by the Axis 1 motor.

Base - The base is the foundation of the entire robot, with the electrical interface of the robot arranged behind it.

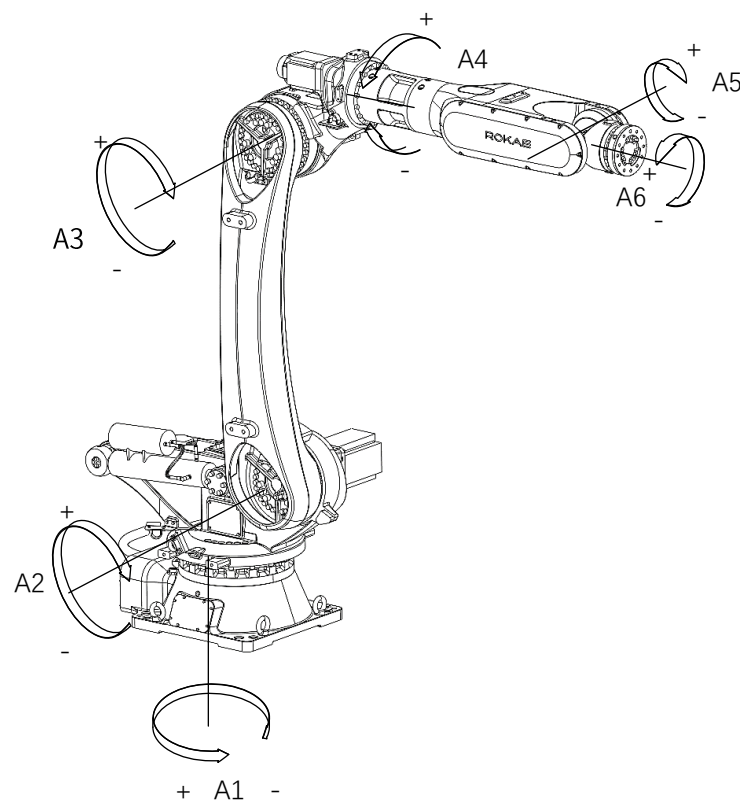


Fig. 3 6-axis robot: Movement direction of each axis

No.	Component name
1	Wrist
2	Upper arm
3	Lower arm
4	Swing joint
5	Base

3.3 Symbols and labels

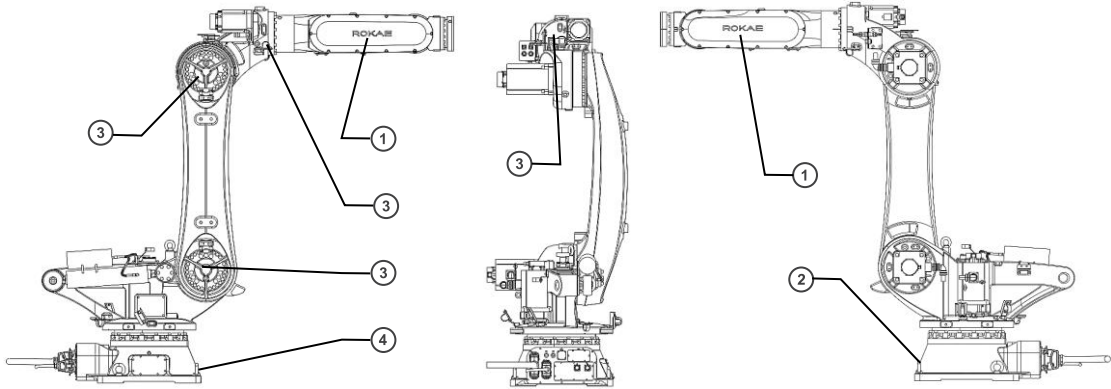






Fig. 4 Symbols and labels

Position	Label type	Remarks	Legend																								
1	Arm body Logo																										
2	Product nameplate	Indicates product information such as product model.	<div><div></div><div>瑞石 (山东) 智能科技有限公司 Rokae (Shandong) Robotics Technology Co., Ltd.</div><table><tr><td>名称</td><td>Name</td><td>XXX</td></tr><tr><td>型号</td><td>Type</td><td>XXX</td></tr><tr><td>序列号</td><td>Serial No.</td><td>XXX</td></tr><tr><td>日期</td><td>Date</td><td>XXX</td></tr><tr><td>重量</td><td>Weight</td><td>XXX</td></tr><tr><td>臂展</td><td>Range</td><td>XXX</td></tr><tr><td>负载</td><td>Payload</td><td>XXX</td></tr><tr><td>精度</td><td>Repeatability</td><td>XXX</td></tr></table><div>Web : www.rokae.com 地址 : 山东省济宁市邹城市恒丰路888号 Add : No.888 Hengfeng Rd.,Zoucheng,Jining,Shandong Made in China</div></div>	名称	Name	XXX	型号	Type	XXX	序列号	Serial No.	XXX	日期	Date	XXX	重量	Weight	XXX	臂展	Range	XXX	负载	Payload	XXX	精度	Repeatability	XXX
名称	Name	XXX																									
型号	Type	XXX																									
序列号	Serial No.	XXX																									
日期	Date	XXX																									
重量	Weight	XXX																									
臂展	Range	XXX																									
负载	Payload	XXX																									
精度	Repeatability	XXX																									
3	Electrical hazard symbol	Do not touch the electrical components inside a live robot to avoid the risk of electric shock.																									
4	Safety alert symbol	Do not enter into the working area while the robot is on, since the robot may collide and cause severe accidents.																									

4 Technical Specifications

4.1 Introduction

This section mainly describes the various performance parameters of the NB220 robot product series.

4.2 Model

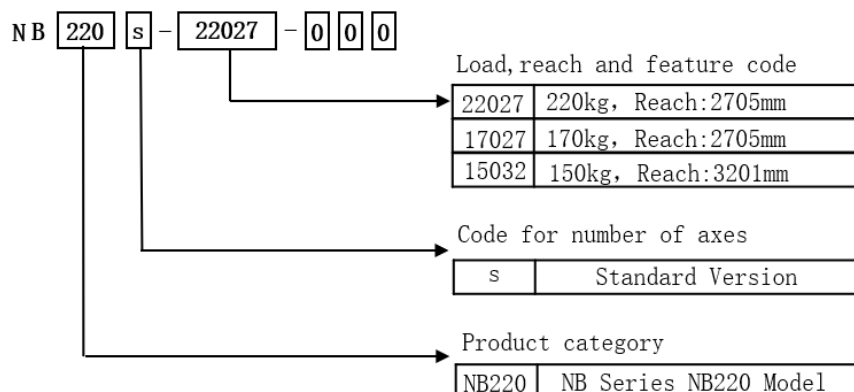



Fig. 5 Model description

4.3 Specification

Product name		NB220-220/2.7	NB220-170/2.7	NB220-150/3.2
DOF		6	6	6
Driving mode		AC Servo	AC Servo	AC Servo
Reach		2705mm	2705mm	3201mm
Repeatability		≤0.06mm	≤0.06mm	≤0.06mm
Wrist payload		220kg	170kg	150kg
Range of motion	A1	±185°	±185°	±180°
	A2	-65°~85°	-65°~85°	+156°~-99°
	A3	-185°~80°	-185°~80°	+75°~-200°
	A4	±200°	±200°	±180°
	A5	±130°	±130°	±135°
	A6	±360°	±360°	±360°
Maximum velocity	A1	120°/s	130°/s	130°/s
	A2	110°/s	115°/s	115°/s
	A3	110°/s	120°/s	120°/s
	A4	150°/s	180°/s	180°/s
	A5	150°/s	180°/s	180°/s
	A6	220°/s	260°/s	260°/s

Product name	NB220-220/2.7	NB220-170/2.7	NB220-150/3.2
Operating temperature	0°C~+45°C	0°C~+45°C	0°C~+45°C
Storage temperature	-10°C~+55°C	-10°C~+55°C	-10°C~+55°C
Protection level	IP65(IP67 for wrist)	IP65(IP67 for wrist)	IP65(IP67 for wrist)
Mounting position	Floor	Floor	Floor
Weight	Approx.1138kg	Approx. 1138kg	Approx. 1165kg
Noise level	≤90dB(A)	≤90dB(A)	≤90dB(A)
Air	2-φ12 air pipe(8bar)	2-φ12 air pipe(8bar)	2-φ12 air pipe(8bar)
Signal	24-way signal (30V, 0.5A)	24-way signal (30V, 0.5A)	24-way signal (30V, 0.5A)

4.4 Allowable wrist payload




Warning

It is very important to always define the correct actual load data and calibrate the payload of the robot. Incorrectly defined load data may result in robot overload.

If incorrect load data and/or loads other than those specified in the load diagram are used, the following components may be damaged due to overload:

- Motor
- Gearbox
- Mechanical structure



Warning

The total weight of all loads mounted on the robot including end flange and upper arm should be less than the maximum payload of the robot.

Robots operating with incorrect load data and/or loads other than those specified in the load diagram shall not be covered by the robot warranty.

4.4.1 Allowable torque and inertia

In order to avoid robot failure and damage caused by overload, the payload installed on the robot is not allowed to exceed the allowable torque and inertia.

For NB220-220/2.7 models, the allowable moment and inertia are shown in the following table:

	Allowable torque	Allowable inertia
Axis 4	1300Nm	145kg.m ²
Axis 5	1300Nm	145kg.m ²
Axis 6	735Nm	85kg.m ²


For NB220-170/2.7 models, the allowable moment and inertia are shown in the following table:

	Allowable torque	Allowable inertia
Axis 4	950Nm	89kg.m ²
Axis 5	950Nm	89kg.m ²

Axis 6	500Nm	46kg.m2
--------	-------	---------

For NB220-150/3.2 models, the allowable moment and inertia are shown in the following table:

	Allowable torque	Allowable inertia
Axis 4	950Nm	89kg.m2
Axis 5	950Nm	89kg.m2
Axis 6	500Nm	46kg.m2



Warning

The total weight of the end tooling fixture and workpiece should be less than the maximum payload of the robot. Make sure to match the load according to the robot's carrying capacity. The load exceeding the carrying capacity of the robot will trigger the alarm or even cause damage to robot components, thereby reducing the robot's service life.

4.4.2 Center of gravity of the load

The position of the center of gravity of the load is determined by the distance between the center of gravity and the flange surface. The distance is illustrated in the figure below. See the Load diagram for the rated distance.

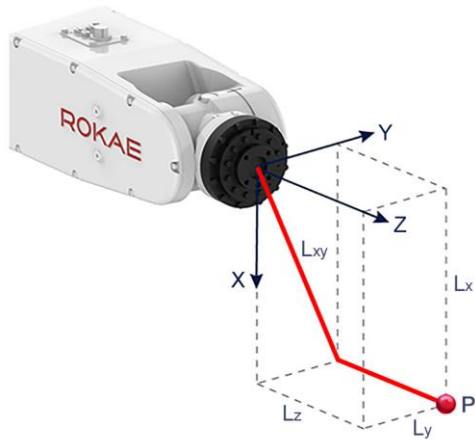


Fig. 6 Center of gravity of the load

4.4.3 Load diagram

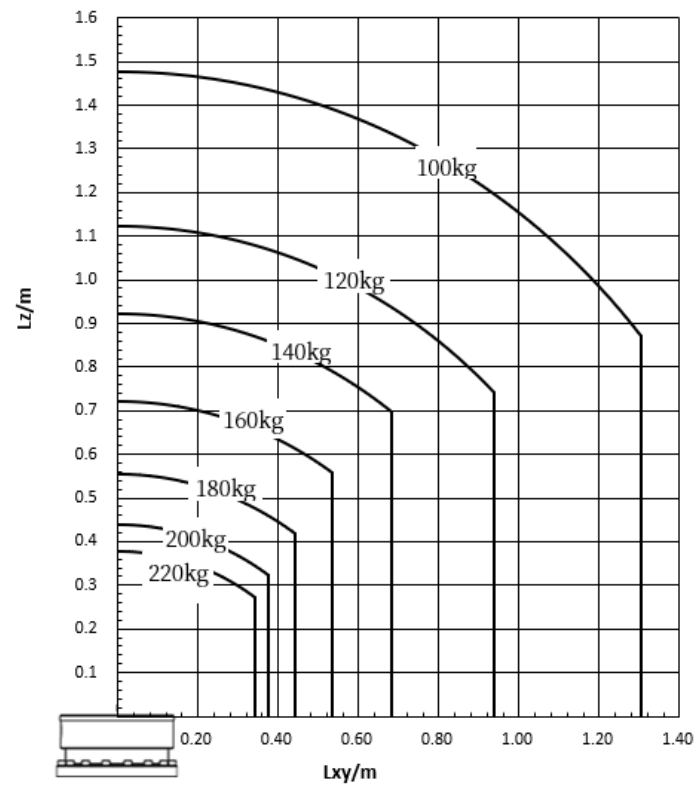


Fig. 7 Load diagram for NB220-220/2.7

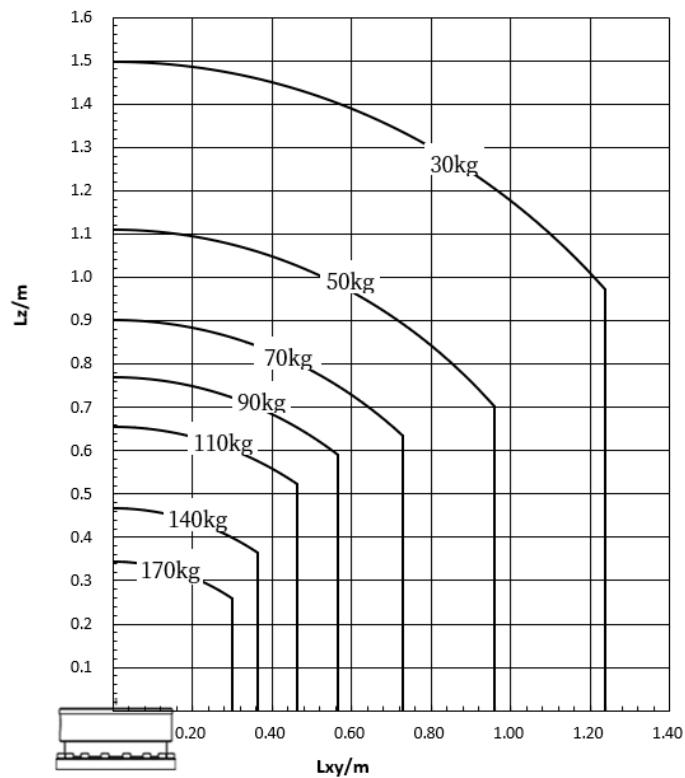


Fig. 8 Load diagram for NB220-170/2.7

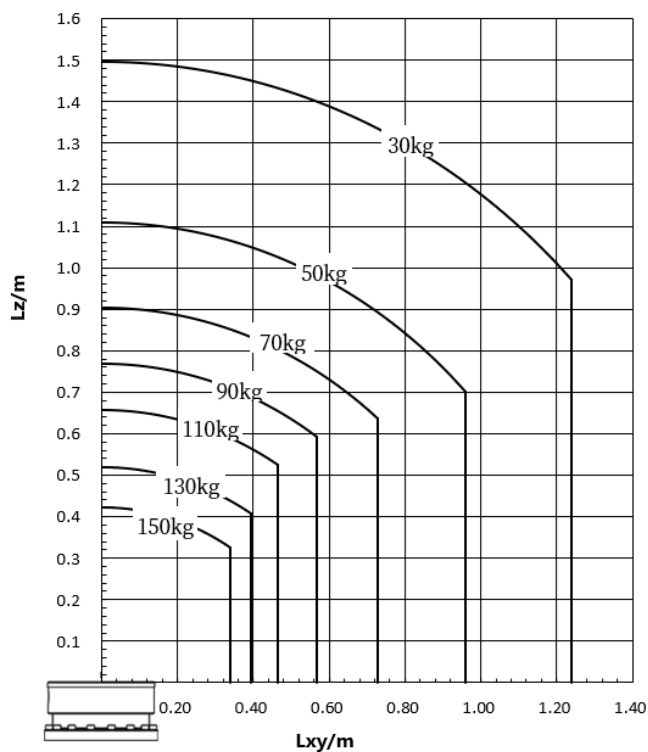


Fig. 9 Load diagram for NB220-150/3.2

4.4.4 Calculating the Inertia Moment

In order to ensure the best performance of the robot, it is necessary to make sure that the load (the weight of the end-effector and the workpiece) and the load inertia are within the allowable value of the robot, and the inertia moment of the actuator must be considered when the end-effector is installed.

The allowable inertia moment of NB220 series robots can be found in 4.4.1. Please calculate the inertia of the load before use and ensure that it is used within the allowable value.



Tips

In general, the mass, centroid and inertia information of the load can be quickly obtained in CAD software!

4.5 Working space

The NB220-220/2.7 working space is shown in the figure below:

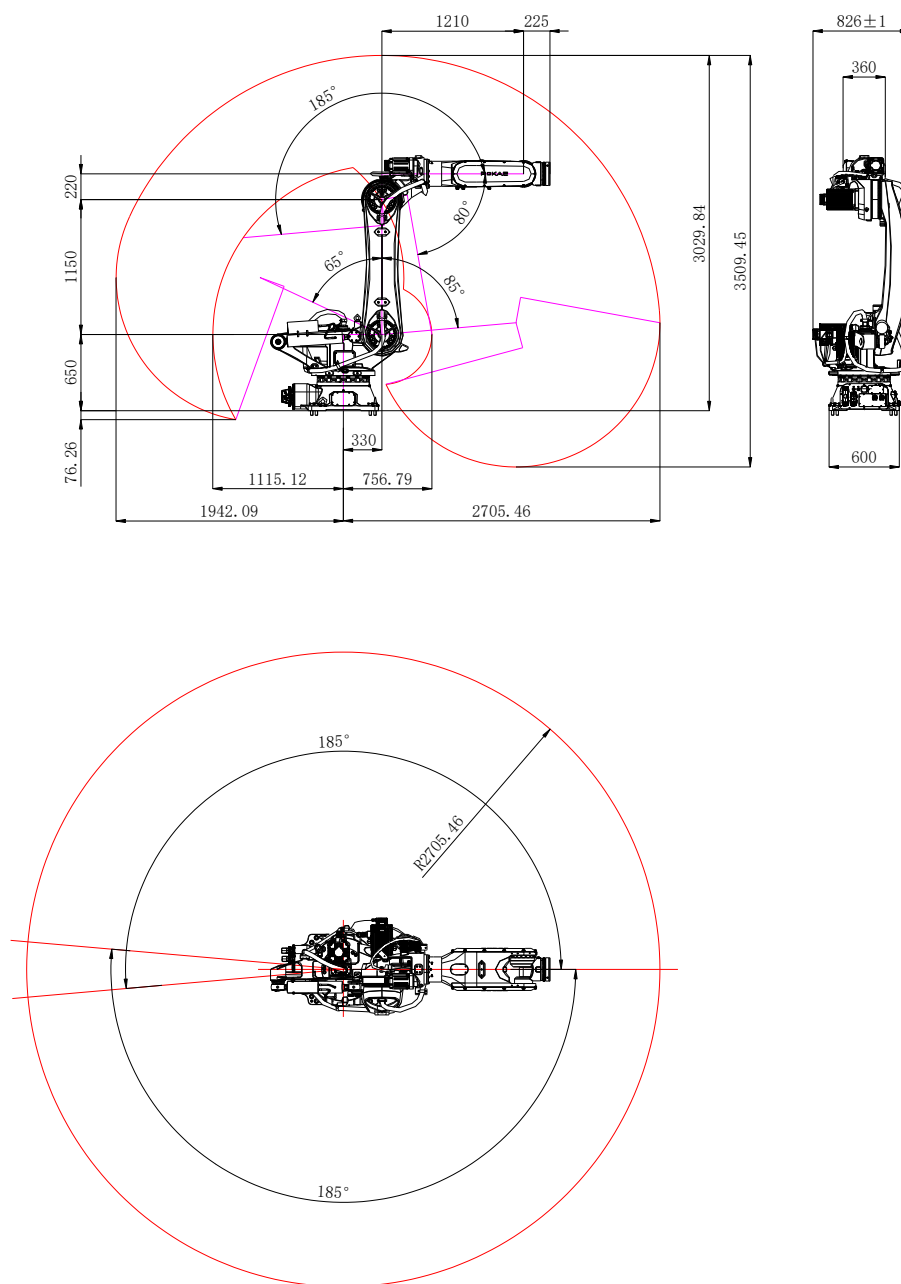


Fig. 10 NB220-220/2.7 working space

The NB220-170/2.7 working space is shown in the figure below:

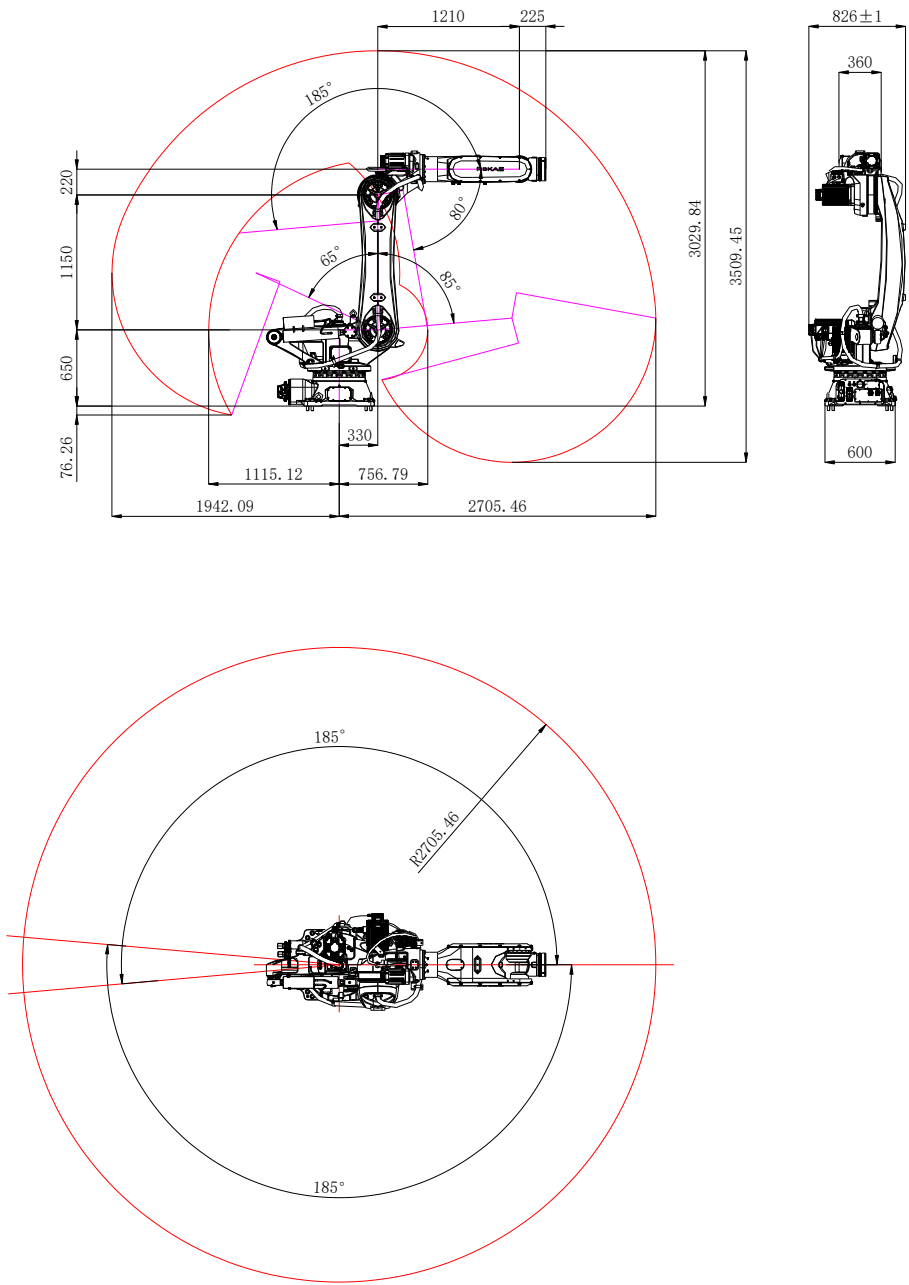


Fig. 11 NB220-170/2.7 working space

The NB220-150/3.2 working space is shown in the figure below:

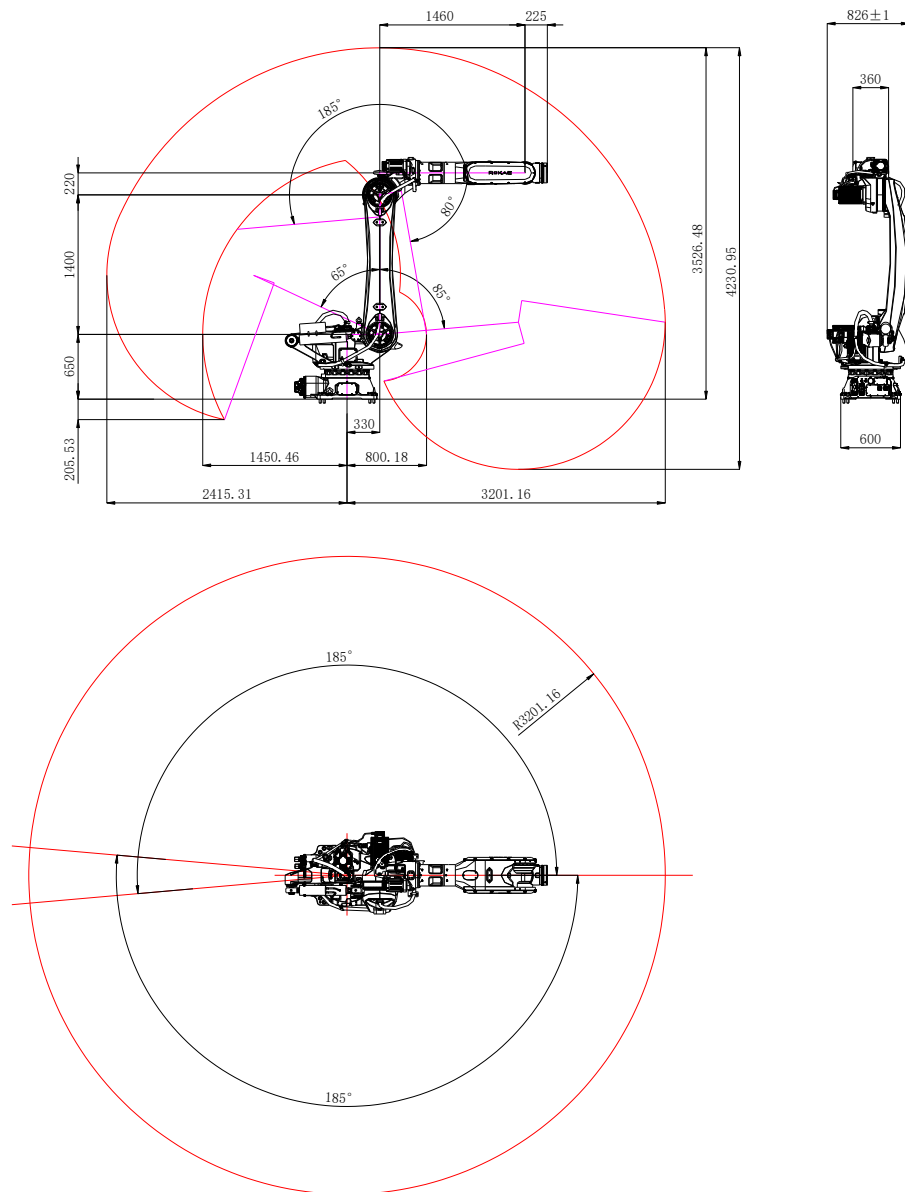


Fig. 12 NB220-150/3.2 working space

4.6 Overall dimensions and mechanical interfaces

Extra load can be applied to the lower arm and upper arm of the NB220 robot series. See the figure below for its mounting interfaces and the interference radius of Axes 1, 3 and 4.

To ensure the service life of the threads, do not remove the interface mounting screws frequently.

The overall dimensions and external interface dimensions of NB220-220/2.7 are shown in the figure below:

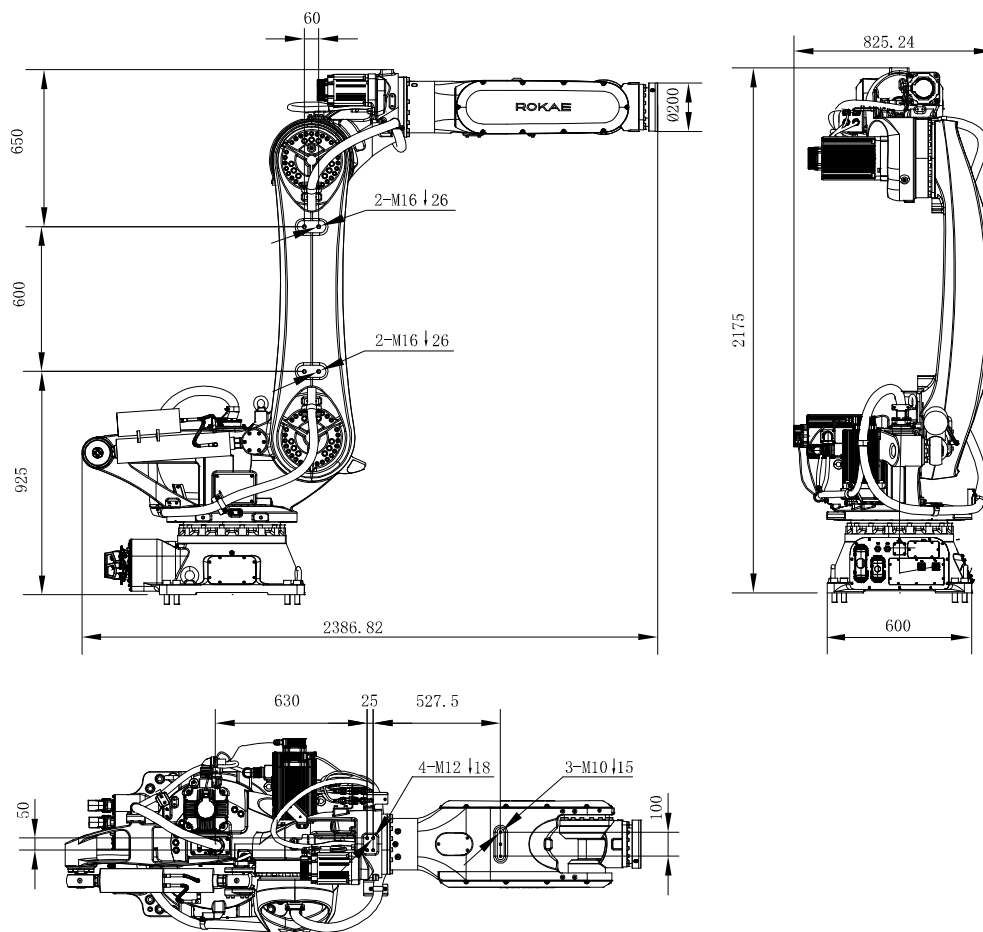


Fig. 13 Overall dimensions and mechanical interfaces of NB220-220/2.7

The overall dimensions and external interface dimensions of NB220-170/2.7 are shown in the figure below:

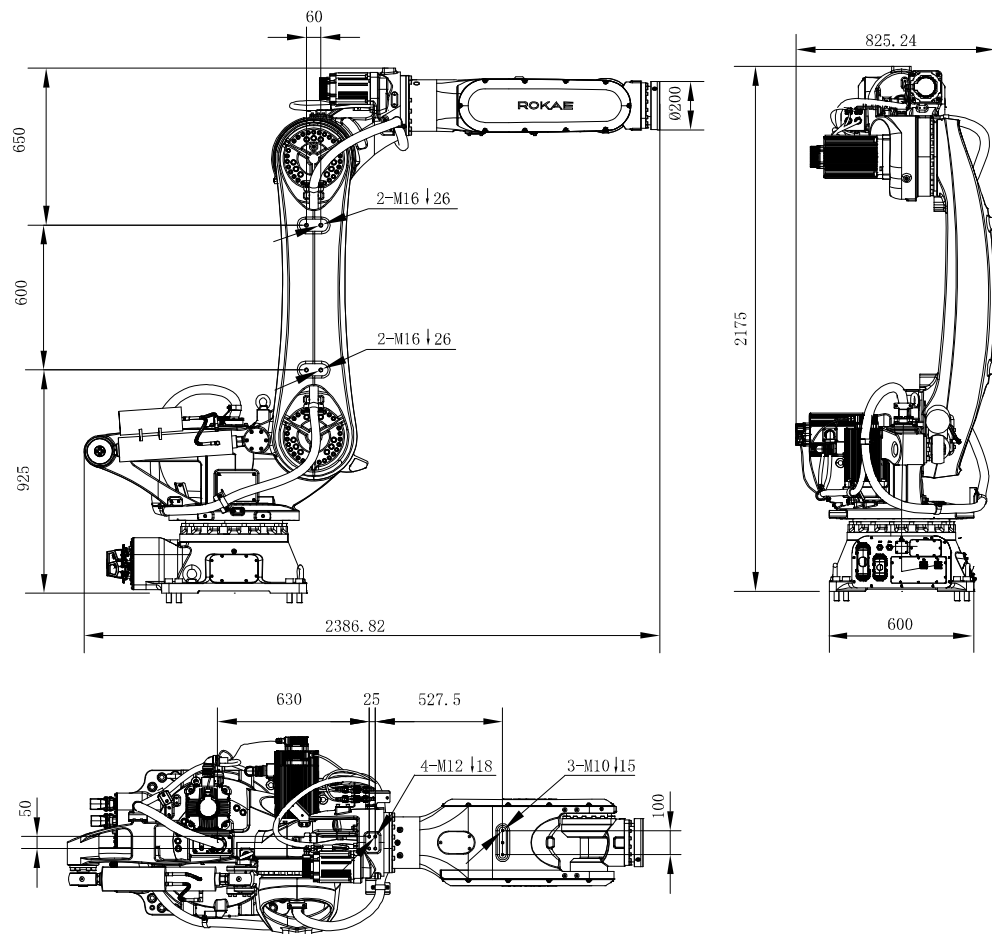


Fig. 14 Overall dimensions and mechanical interfaces of NB220-170/2.7

The overall dimensions and external interface dimensions of NB220-150/3.2 are shown in the figure below:

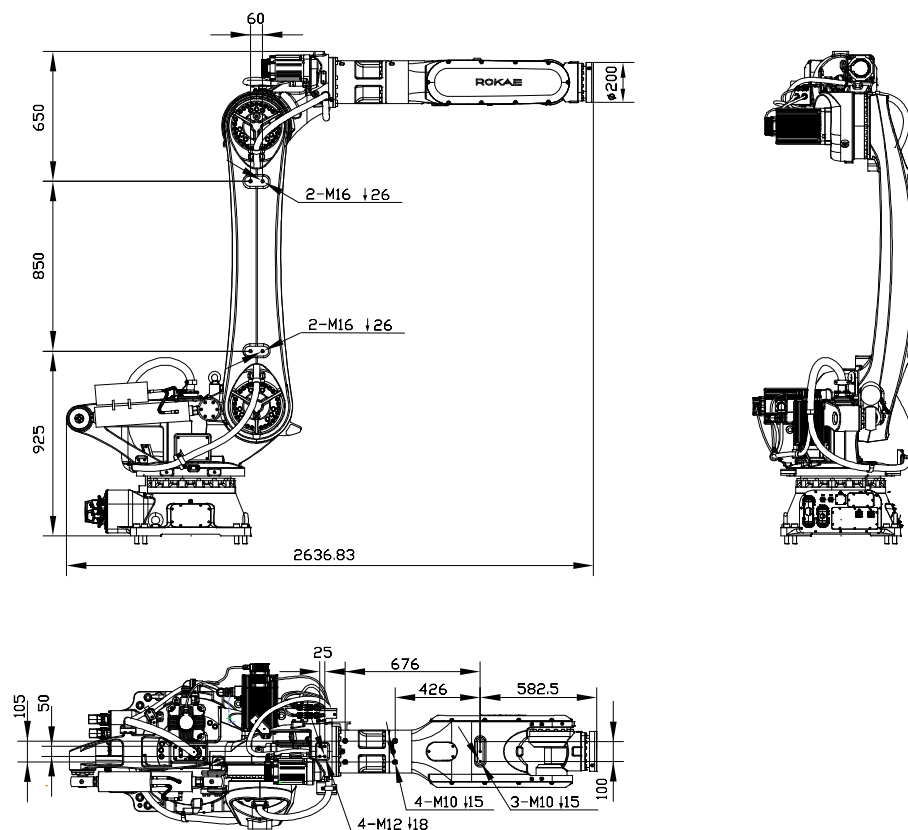


Fig. 15 Overall dimensions and mechanical interfaces of NB220-150/3.2

4.7 Mounting flange

The user should fabricate a robot end fixture according to actual needs and connect it to the wrist mounting flange. The size of the mounting flange is shown in the figure below. The socket head cap screw has a fixing strength of 12.9. The shape and size of the mounting fixture on the mounting flange may affect the rotation range of the robot axis. Pay attention to the interference zone at the end of the fixture during design.

The mounting flange of NB220-220/2.7、NB220-170/2.7、NB220-150/3.2 robots is shown in the figure below:

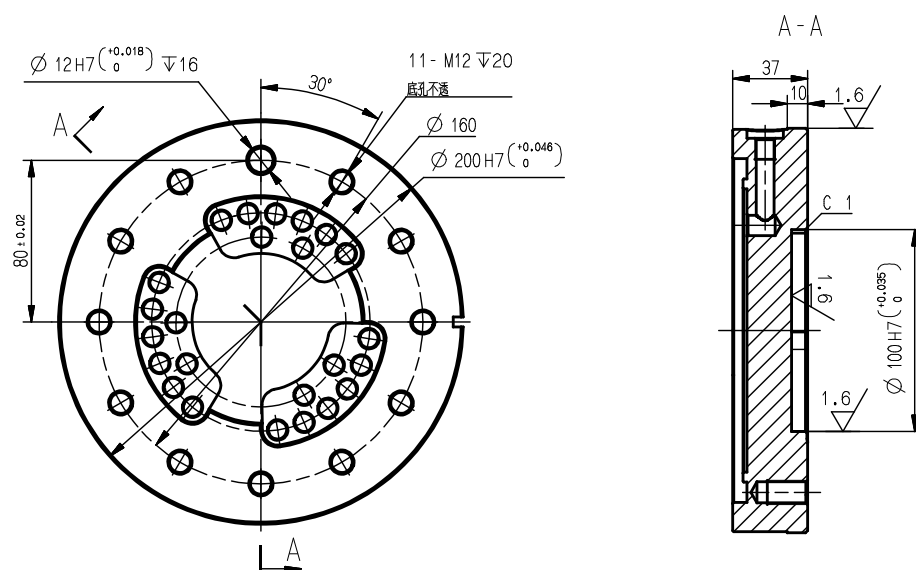


Fig. 16 Mounting flange

5 Environment and Installation

5.1 Introduction

This section mainly describes the relevant information to be paid attention to during the installation of the NB80 robot series. Transportation and installation of the robot and related equipment should be carried out by qualified personnel. In addition, make sure to work in accordance with the laws and regulations in your country.

5.2 Installation process table

The installation process table is used to check the robot installation progress. Put a check mark in the "Completed" column when a step is finished.

Step	Operation	Completed
1. Preparation before the installation		
①	Installation personnel	
②	Installation environment	
③	Installation foundation	
④	Support pillar	
2. Installation dimensions		
3. Unpacking and handling		
①	Unpacking	
②	Check the packing list	
③	Handling	
4. Installing the robot arm body		
①	Fix the robot in the installation position	
5. Cable connection		
①	Connect the power supply and signal cables between the robot arm body and the control cabinet	
6. User wiring/routing		
①	Connect the I/O signal cable and air pipe	

5.3 Environmental conditions

The robot is suitable for general industrial environments, which should meet the following conditions:

Item	Condition
Temperature	0°C~+45°C
Relative humidity	20%~80%, no condensation
Electrical fast transient (EFT)	Below ±2kV

Item	Condition
Electro-Static discharge (ESD)	Below $\pm 8\text{kV}$
Environment	Indoor installation. Avoid exposure to sunlight. Keep away from dust, soot, salt, iron chips, etc. Keep away from flammable and corrosive liquids and gases. Do not contact with water. Do not transfer shock and vibration. Keep away from sources of electrical interference.



Warning

Never place or use the robot in any explosive environment!



Tips

In the case of low ambient temperature ($<10^{\circ}\text{C}$), the viscosity of grease (or lubricating oil) in the reducer (or gearbox) is high, which may cause the robot to stop or run inefficiently. It is recommended to preheat the robot and other auxiliary equipment together.

Please contact us for use in environments that do not meet the above conditions.

The storage environment of the robot should meet the following conditions:

Item	Condition
Temperature	$-10^{\circ}\text{C}\sim+55^{\circ}\text{C}$
Relative humidity	20%~80%, no condensation

5.4 Unpacking

5.4.1 Unpacking

Prepare necessary tools for unpacking according to the table below.

No.	Tool	Quantity
1	Steel strip scissors	1
2	Utility knife/scissors	1
3	M20 outer hex wrench	1
4	Protective gloves	1

Unpacking procedures:

① Step 1: Open the wooden packaging box

Put on a pair of protective gloves, remove the fixed bolts, and move the wooden box upwards to separate the wooden box from the bottom pallet.

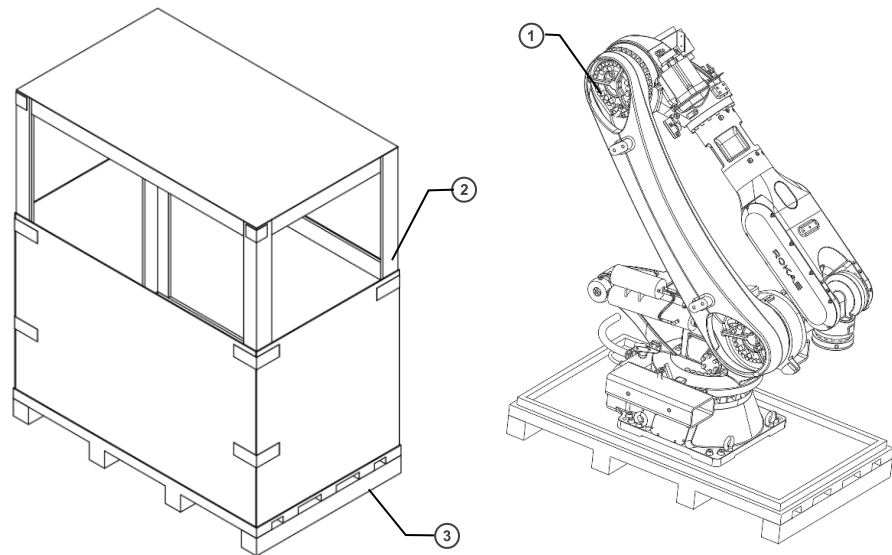


Fig. 17 Unpacking the wooden box

No.	Name
1	Robot body
2	Box
3	Bottom pallet

② Step 2: Remove the packaging of the control cabinet and the Teach Pendant cardboard box

Use a pair of scissors to cut off the packing straps fixing the Teach Pendant cardboard box and control cabinet;

Move the Teach Pendant cardboard box and control cabinet from the bottom pallet of the wooden box to open ground. Be careful of the directions and handle gently;

Use a pair of scissors to cut off the sealing tapes of the cardboard box, open the cardboard box, and take out the Teach Pendant cable, the Teach Pendant and the robot cable under the Teach Pendant foam.

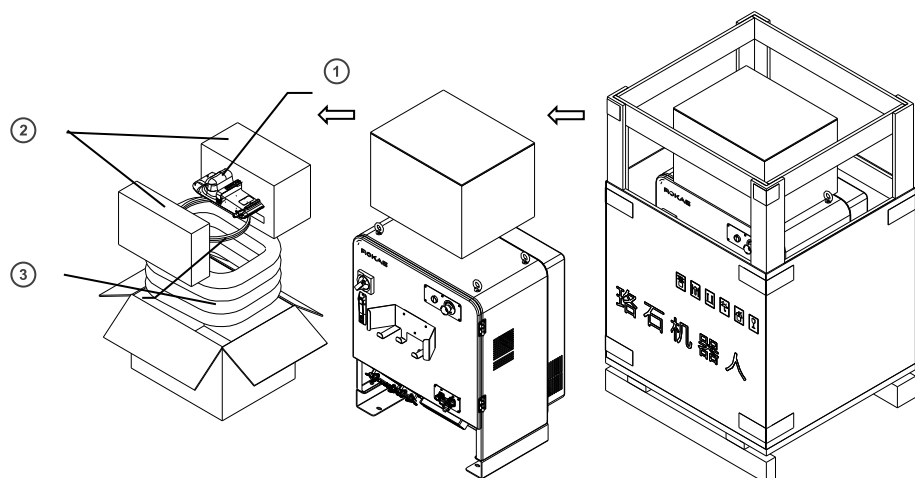


Fig. 18 Unpacking the control cabinet and the Teach Pendant cardboard box

No.	Name
1	Teach Pendant
2	Foam
3	Robot cable

③ Step 3: Remove the bolts that fix the robot arm body

Use an M12 external hex wrench to remove the four nuts that fix the robot. Unscrew them and move the robot arm body to the designated safe position.

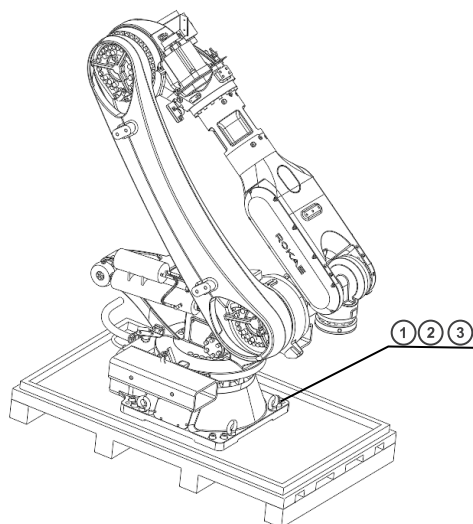


Fig.19 Unpacking the robot body

No.	Name	Specifications	Quantity
1	Hexagon head wood screw	M16*180mm	8
2	Washer	Inner diameter 16, outer diameter 40, thickness3	8
3	Washer	Inner diameter 16, outer diameter 50, thickness3	8



Warning

When removing bolts from the robot arm body, one person should hold the robot equipment while another person conduct the removal to prevent the equipment from tilting due to unstable center of gravity, which might result in personal injury or equipment damage. Handle the robot arm body carefully after removing the bolts.

5.4.2 Robot transportation angle

To ensure stability during transportation, the transportation pose and angle of each axis are defined. The detailed transportation pose and angle for each model are listed below.

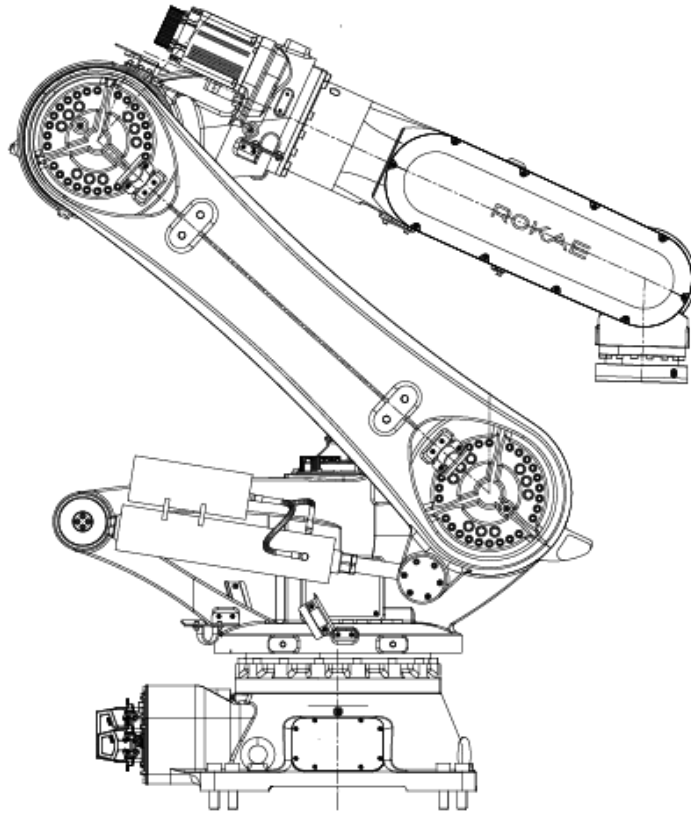


Fig. 20 Robot transportation angle

Model	Rotation angle of each axis in the packaging pose relative to the zero pose					
	A1	A2	A3	A4	A5	A6
NB220-220/2.7	0°	-48°	72°	0°	66°	0°
NB220-170/2.7	0°	-48°	72°	0°	66°	0°
NB220-150/3.2	0°	-39.5°	80°	0°	49.5°	0°

5.4.3 Inspection before the transportation

The installation personnel who installs and operates the robot must have the necessary knowledge for installation, maintenance and repair of mechanical and electronic equipment, and must comply with all the relevant specifications of the country/region.

NO.	Item
1	Visually inspect the robot appearance for bumping and damage
2	Ensure that the lifting device and equipment match the robot model
3	Robots not installed directly should be stored according to "5.3 Environmental conditions"
4	Make sure that the environmental conditions

	for installing the robot conform to the descriptions in "5.3 Environmental conditions"
5	Before moving the robot, check its stability and refer to "5.5.1.2 Tilt risk"
6	Once the above conditions are met, you can move it to the installation site according to the descriptions in the next section

5.5 On-site installation

5.5.1 Handling

5.5.1.1 General description

In principle, lifting equipment such as a traveling crane should be used during the handling. Crane and forklift should be operated by professionals with operational qualification. Otherwise, accidents such as personal injury and equipment damage may occur.

5.5.1.2 Tilt risk

If the robot is not fixed on any base and stays stationary, it is unstable and any movement operation may cause its center of gravity to shift or tilt, or even result in rollover.

The transportation pose is the most stable pose for the robot. Do not change it before the robot is fixed on the base.

5.5.1.3 Handling dimensions

Fig. 21 shows the contour size of the robot in the transportation posture, in which dimensions C and D indicate the center of gravity position of the robot for reference in transportation.

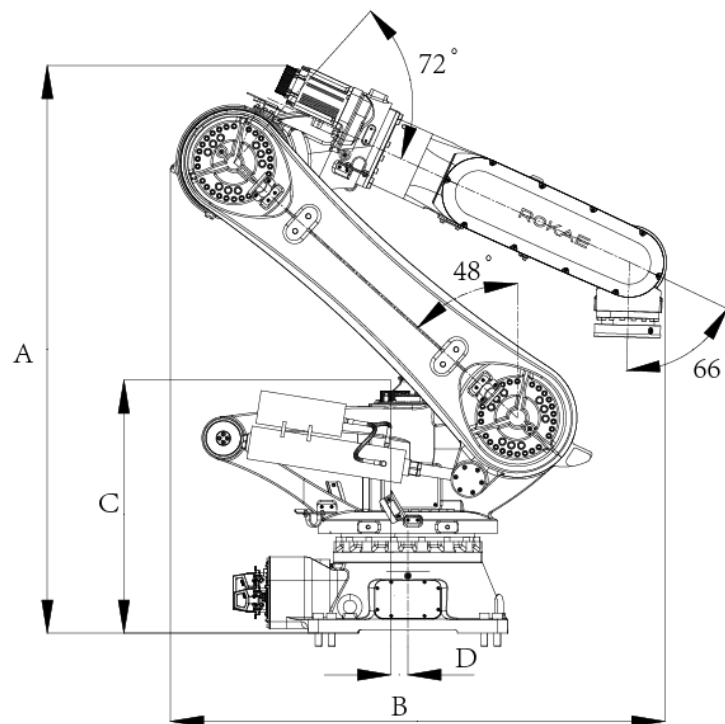



Fig. 21 Reference handling dimensions of the NB220 series

Model	A/mm	B/mm	C/mm	D/mm
NB220-220/2.7	1712.80	1491.26	767.70	1.5
NB220-170/2.7	1712.80	1491.26	767.70	1.5
NB220-150/3.2	1970	1545	838.14	0.16


5.5.1.4 Crane

In principle, a crane should be used to move and handle the robot. It is necessary to pay attention to safety and handle it gently so as not to damage the equipment or the surface of the robot.




Warning

The weight of the NB220-220/2.7 robot is about 1138 kg. Please be sure to use a lifting hook and lifting rope with a bearing strength of 3000 kg or more. It is recommended to use a sling or protected steel wire rope as the lifting rope to prevent the lifting rope from damaging the arm body painting. Lifting the robot at any position other than the recommended position may cause the robot to tip over and result in serious damage or injury!



Warning

In no case shall any person be allowed to stand below the place where the robot is being lifted.



Warning

Be sure to turn off all the power, hydraulic and air sources of the robot during the transportation.

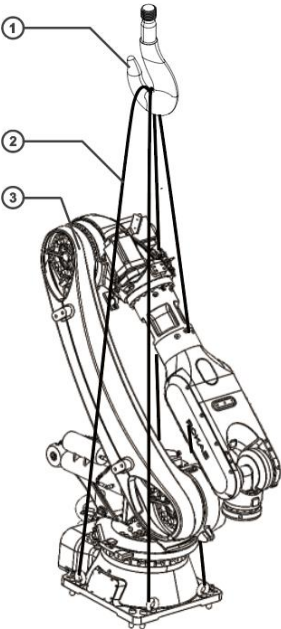


Fig. 22 Robot lifting and handling

No.	Component
1	Lifting hook

2	Lifting rope
3	Robot body

5.5.1.5 Forklift

During handing the robot using a forklift, fix the robot on the bottom pallet of the packaging box or other baseboards with sufficient carrying capacity with screws, insert the forklift forks under the bottom pallet or baseboard, and handle them together with the robot. Be careful not to tilt during the handling and transport slowly.

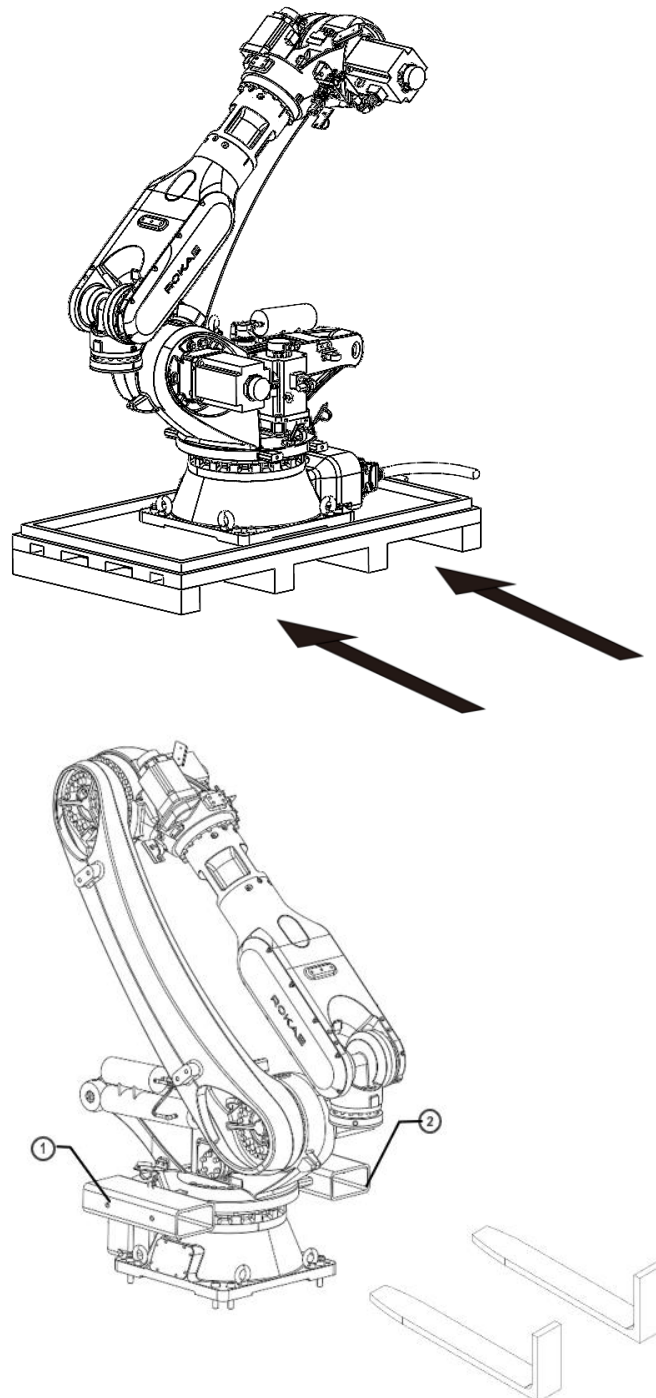


Fig. 23 Handling the robot with forklift

	Description
1	Screw 4-M12x25 (Strength grade 12.9)
2	Transport bracket, 2 pcs

**Warning**

When handling the robot using the bottom pallet and forklift, be careful about the counterweight on both sides of the bottom pallet to prevent rollover.

5.5.2 Robot installation

**Warning**

- Performing work such as installation, wiring, maintenance and repair on the robot equipment by non-professional and unqualified personnel is strictly prohibited;
- Make sure to set a safety fence at the installation position of the robot equipment to avoid safety problems;
- Make sure to check the equipment installation space. Setting up the robot within a limited space will confine its motion and cause severe injury or accidents;
- Before powering up the robot equipment, make sure that the equipment is fixed, otherwise, the equipment may tip over and cause critical damage.

**Warning**

- When installing the robot on the floor (frontal installation), make sure to have at least two people to complete the installation work;
- When installing the robot on the wall (inverted installation), make sure to have at least four people to complete the installation work and use lifting equipment in order to avoid dangers;
- When removing any screws from the robot equipment, hold the robot steady in order to prevent rollover;
- Retrofitting or disassembling the equipment is prohibited. If disassembly is necessary, please contact us.

5.5.3 Parts required for fixing

Part name	Details	Foundation installation
Fixing screw	8-M20x80 (Grade 12.9)	✓
Expansion bolt (chemical bolt)	4-M20 (no less than Grade 8.8)	✓
Robot fixing plate	Thickness at least 42mm	✓

Notes:

1. No insulating layer material is allowed between the robot fixing plate/mounting seat and the manipulator/concrete;
2. "✓" indicates the requirements of this installation method;
3. The fixing strength of the mounting bracket shall not be lower than that of the robot fixing plate and the foundation during the foundation installation.

5.5.4 Foundation installation

When the foundation installation method is selected, see the figure below for the installation and adaptation dimensions of NB220:

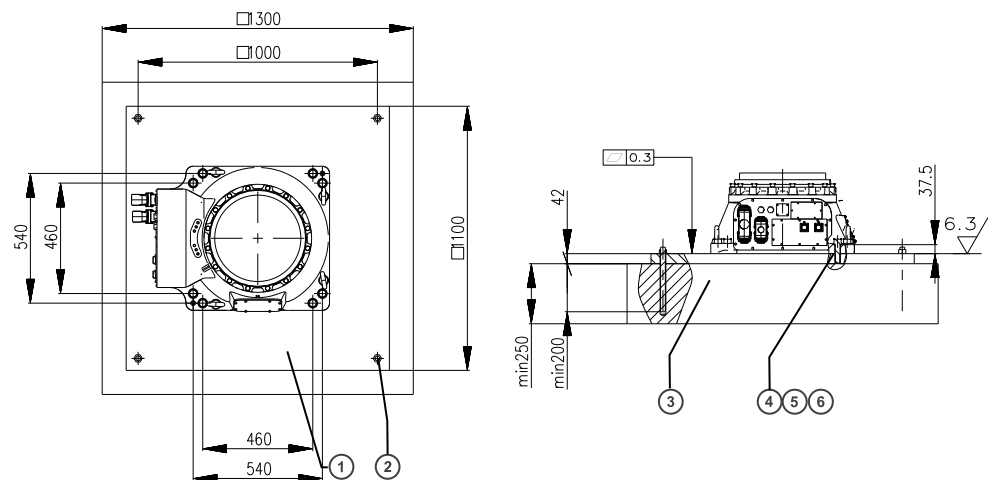


Fig. 24 Foundation fixing method

No.	Description
1	Adaptation plate
2	Chemical bolt (expansion bolt) M20
3	Foundation
4	Socket head cap bolt M16X50
5	Flat washer

Mount the adaptation plate onto the foundation with four M20 chemical bolts (expansion bolts), then fix the robot base onto the adaptation plate with 8 socket head cap bolts M20x80. Tightening torque: 670±5 Nm.



Warning

- When the foundation installation method is adopted, make sure that the foundation offers sufficient strength. For the torque and supporting reaction force generated by the robot, refer to "5.5.5 Supporting reaction force of the robot";
- No insulating layer material is allowed between the adaptation plate and the foundation.

5.5.5 Robot supporting reaction force

After the robot is installed, its mounting base will generate a large supporting reaction force due to the static force and dynamic force of the robot, as shown in Figure 26.

Therefore, the robot base must be able to bear this supporting reaction force.

Name	Description
F_{xy}/N	Force along any direction in the XY-plane
F_z/N	Force in the Z-plane
M_{xy}/Nm	Bending torque along any direction in the XY-plane
M_z/Nm	Bending torque in the Z-plane

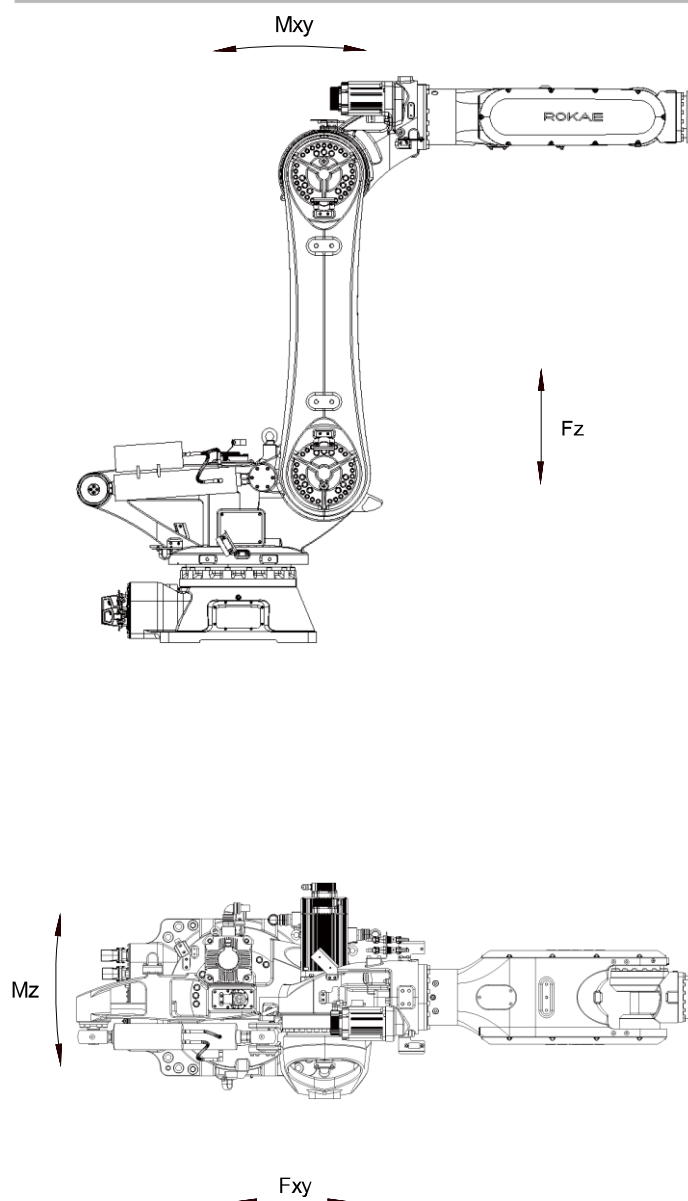


Fig. 25 Supporting reaction force of the robot

Force	Maximum load	Maximum load	Maximum load
Fxy/N	8100.163	8534.738	9367.60
Fz/N	16388.07	15898.07	15886.45
Mxy/Nm	24927.75	23290.22	25626.24
Mz/Nm	16500.40	14824.73	16896.24



Tips

The above force and torque data are the limit values that may appear during the motion of the robot. The limit values occur seldom and cannot be reached at the same time.

5.6 Electrical connection



Warning

- When connecting the robot and controller, make sure that the connection is correct. Otherwise, the robot system may not operate properly, and safety problems may also be caused. For details, refer to the controller manual.
- The wiring work must be carried out by certified operators or qualified personnel. If the wiring work is performed by someone who does not have the relevant knowledge, injury or malfunction may occur.



Warning

- Be sure to perform the replacement operation after powering off the controller and related devices and unplugging the power plug. If you operate while the power is on, electric shock or malfunction may occur.
- Be sure to connect the AC power cable to the power plug. Do not connect it directly to the service power source. Never turn off the robot system by unplugging the power plug. It is extremely dangerous to operate when the AC power cable is connected to the service power source, which may result in electric shock and/or failure of the robot system.
- Be careful not to forcibly bend the cable, etc. to avoid applying load to the cable. Also, do not place heavy objects on the cable and forcibly bend or pull the cable. Otherwise, cable damage, disconnection or poor contact may occur, thus resulting in electric shock or abnormal system action.
- Before wiring, power off the controller and related devices and place a warning symbol (e.g. do not turn on the power). Wiring when the power is on is extremely dangerous and may cause electric shock and/or failure of the robot system.
- Make sure that the equipment is properly grounded to avoid the risk of electric shock.

5.6.1 Definition of the robot arm body side ports

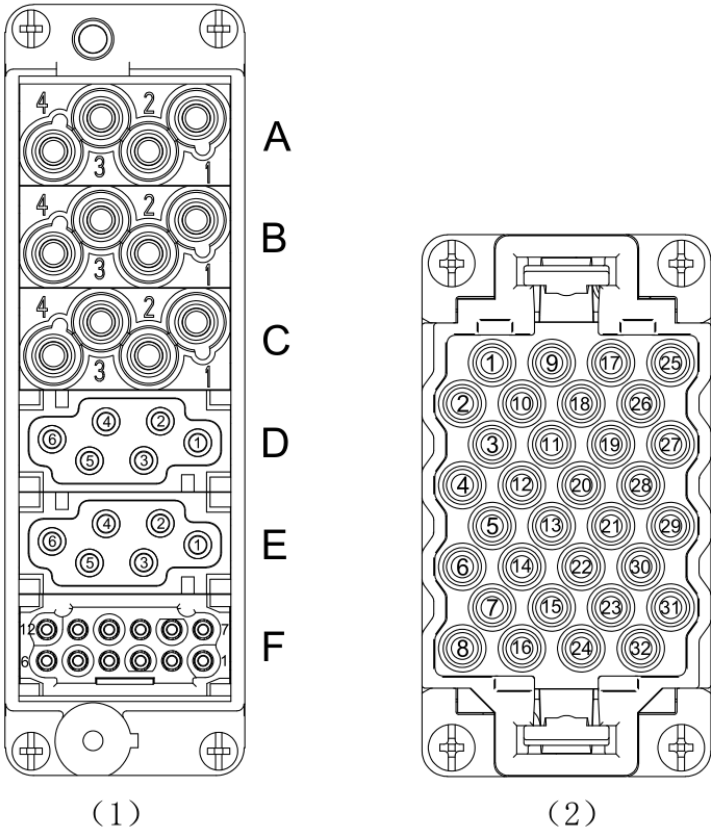


Fig. 26 Definition of the robot arm body side ports

No.	Meaning
1	Power port definition
2	Signal port definition

Power			Signal		
PIN	Function	Use	PIN	Description	Use
A-1	Axis 1	U1	1	Encoder Axis 1	VCC1
A-2		V1	9		GND1
A-3		W1	17		DATA1-
A-4		PE1	25		DATA1+
B-1	Axis 2	U2	2	Encoder Axis 2	VCC2
B-2		V2	10		GND2
B-3		W2	18		DATA2-
B-4		PE2	26		DATA2+
C-1	Axis 3	U3	3	Encoder Axis 3	VCC3
C-2		V3	11		GND3
C-3		W3	19		DATA3-
C-4		PE3	27		DATA3+
D-1	Axis 4	U4	4	Encoder Axis 4	VCC4
D-2		V4	12		GND4
D-3		W4	20		DATA4-
D-4		PE4	28		DATA4+
D-5	Axis 5	U5	5	Encoder Axis 5	VCC5
D-6		V5	13		GND5
E-1		W5	21		DATA5-
E-2		PE5	29		DATA5+
E-3	Axis 6	U6	6	Encoder Axis 6	VCC6
E-4		V6	14		GND6
E-5		W6	22		DATA6-
E-6		PE6	30		DATA6+
F-5	Ind-type bra	BK1+	7	RS485	
F-6		BK2+	15		
F-7		BK3+	23		
F-8		BK4+	31		
F-9		BK5+			
F-10		BK6+			
F-1	24V Power supply	24V+			
F-3		24V-			

图 27 Power and signal

5.6.2 Definition of EE and AS pins

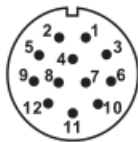


Figure 28 Definition of EE and AS pins

Base EE	Upper:arm EE	Base AS	Upper arm AS
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9
10	10	10	10
11	11	11	11
12	12	12	12

Figure 29 Schematic diagram of the connection inside the robot.

Connection of 12-pin IO interfaces between upper arm EE and base EE, upper arm AS and base AS:

Pins 1-12 are directly-connected internal pins. The user can customize the pin function;

5.6.3 Cabinet cable length and wiring method

Configuration Description	Cable Length
NB220 standard	8m
Optional	15m
Optional	25m



Warning

- An extra length of the cable should be left at the fitting during wiring. Do not tension the cable. A turning radius should be reserved during use, which should be 10 times the cable diameter (approx. 250mm);
- Do not wind up the redundant cable. When the cable is wound up for more than two turns, the heat cannot dissipate and may damage the cable due to excessively high temperature;
- When connecting a heavy-duty connector, pay attention to the direction of the male and female ends. Do not forcibly connect a heavy-duty connector, since the pins may be damaged.

5.7 User wiring/routing



Warning

The wiring work must be carried out by certified operators or qualified personnel. If the wiring work is performed by someone who does not have the relevant knowledge, injury or malfunction may occur.



Warning

- The grounding terminal must be connected to the grounding electrode (it is recommended to use a grounding wire with diameter of 5.5mm or more) so as to avoid accidents such as fire and electric shock.
- Before wiring, power off the controller and related devices and place a warning symbol (e.g. do not turn on the power). Wiring when the power is on is extremely dangerous and may cause electric shock and/or failure of the robot system.

When wiring, users shall refer to the location of each pipe interface in the following figure.

The specifications of the IO cable plugs are shown in the following table.

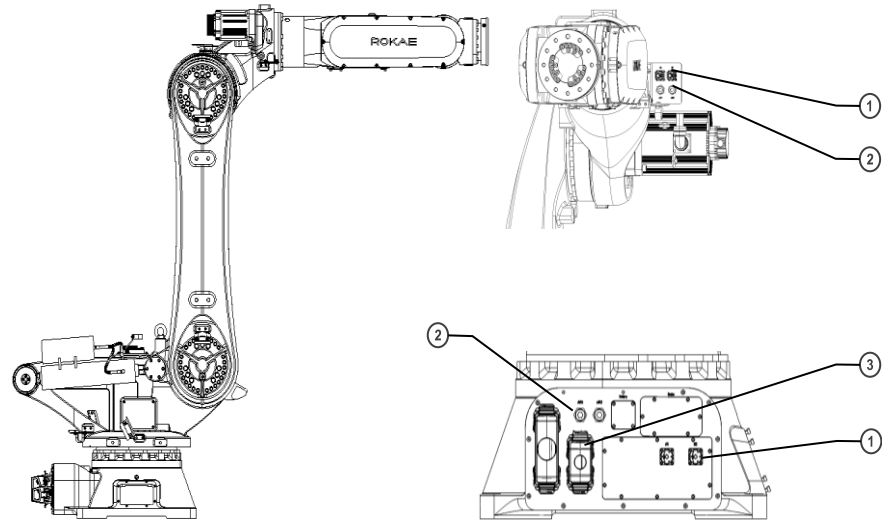


Figure 30 NB220-220/2.7 user wiring/routing

No.	Name	Specifications	Note
1	AS EE	12-way signal (30V, 1A) 12-way signal (30V, 1A)	
2	Air pipe	2* ϕ 12 air pipe	不大于 0.8MPa
3	Heavy-duty connector	-	-

5.8 Brake release

In order to facilitate debugging and maintenance, NB220 series robot has brake release buttons on the base. The operation steps are as follows:

- 1) Remove the 6-M3 screws on the brake release cover;
- 2) Open the brake release cover;
- 3) Press the enabling button "EN" and the releasing button of corresponding shaft number to release the brake.
- 4) Install the brake release cover.

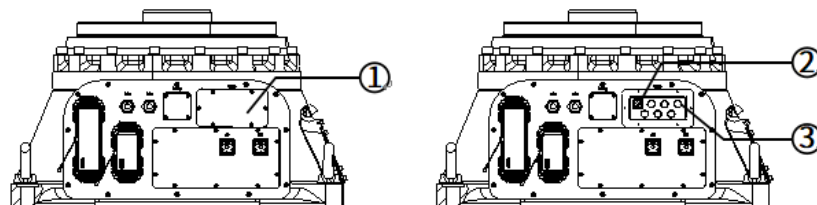


Fig. 31 Brake Release(NB220-220/2.7、NB220-170/2.7、NB220-150/3.2)

	Description
1	Brake release cover
2	Enabling button

3	Brake Releasing Button
---	------------------------

**Danger**

The brake release operation should be carried out by authorized or qualified personnel. Before the brake release of A2 and A3 joints, please use tools such as crane to fix the lower arm and forearm; otherwise, the arms will fall down due to the brake release, resulting in personal injury or equipment damage.

6 Zero calibration

6.1.1 Overview

This section describes the zero calibration. Use the calibration tools described in this section during calibration.

6.1.2 What is a mechanical zero?

The robot is pre-defined with an initial pose during its design, in which the angle of each joint is zero. From a mechanical viewpoint, the zero pose refers to the pose when a certain inclined angle is formed between adjacent links. And for the software, since the robot uses the encoder to record the joint angle, the zero pose refers to the robot's pose when the servo motor rotates to a specific encoder value. Therefore, mechanical zero can be explained in two ways:

- From the perspective of the observer, the mechanical zero is the robot pose corresponding to the specific position each joint of the robot moves to;
- and from the perspective of the control system, the mechanical zero is the value of several encoders.

6.1.3 What is zero calibration?

The zero point is the reference of a robot coordinate system. Without it, the robot cannot determine its own position. Therefore, in order to achieve the best absolute positioning accuracy and allow the link system to be able to correctly reflect the control system position and velocity instructions, the robot must be zero-calibrated so that the mechanical zero and the algorithm zero will get as close as possible.

Generally speaking, a zero calibration is to use certain pre-designed positioning devices on the mechanical arm body to rotate the joints of the robot to a specific angle, and notify the control system to record the value of each joint motor encoder at this time.

6.1.3.1 Mechanical calibration

Mechanical calibration refers to the method of zero point calibration by mechanical contact or other instrument calibration, including key calibration, pin calibration, laser tracker calibration and other calibration methods.

6.1.3.2 Software calibration

Servo motor adopts multiturn absolute encoder, which is realized by single turn absolute encoder + multiturn value (multiturn value needs to be saved with electricity, and will be lost after power failure). After the first mechanical calibration, the control system has recorded the encoder value at zero position (including multiturn value and single turn value). When multiturn value is lost (such as encoder battery discharge), jog the robot to the zero mark on each axis and make sure they are aligned, and this will make each axis move to the same single turn as the mechanical calibration for the first time (may be the multiturn value is different from the first time, but the accurate single turn value has been recorded in the control system). Then calibrate each axis (just click the corresponding calibration button on HMI to record the multiturn value of the encoder), which can ensure that the zero position after calibration is exactly the same as the first mechanical calibration.

So this calibration method is called software calibration without mechanical calibration tools.

6.1.4 When is zero calibration required?

6.1.4.1 When the mechanical transmission system fails

A mechanical calibration must be performed using specific calibration tools in case of the following circumstances:

- After replacing mechanical system parts such as motors, timing belts, reducers, etc.;
- After a violent collision;
- After replacing the robot arm.

6.1.4.2 When multiturn value of the encoder is lost

A software calibration can be performed in case of the following circumstances:

- After the encoder battery is discharged.

6.2 Calibration method

6.2.1 Calibration position

When leaving the factory, the zero point of the robot is calibrated using specific tools as shown in the figure below. If the user has higher requirements for the path and trajectory accuracy and needs to accurately calibrate the Axis 6 zero point (please specify when ordering). It is recommended to design a $5(+0.02,+0.05)$ mm keyway on the end tool flange to cope with the calibration tool.

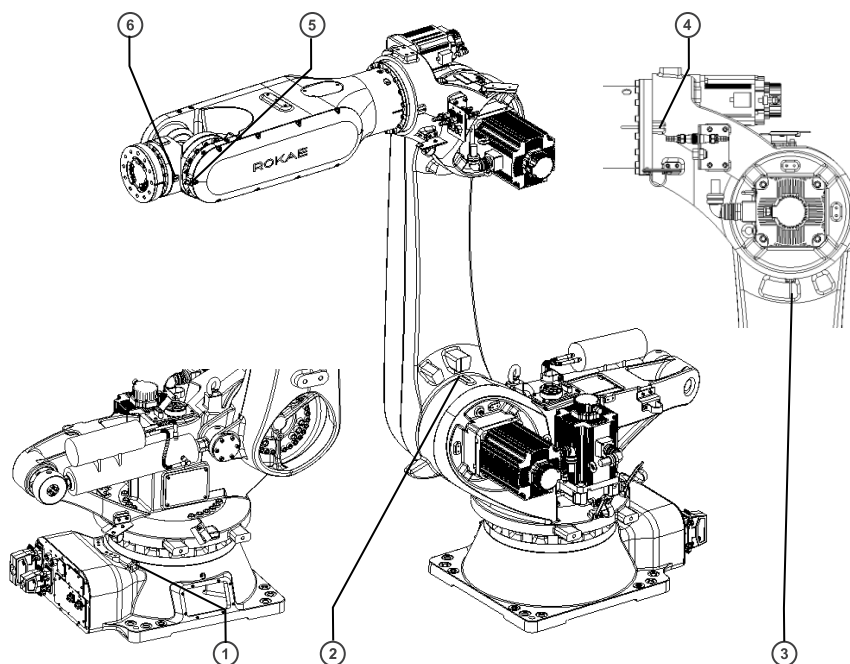


Fig. 32 Calibration method

NO.	Position
1	Axis 1 calibration position
2	Axis 2 calibration position
3	Axis 3 calibration position

NO.	Position
4	Axis 4 calibration position
5	Axis 5 calibration position
6	Axis 6 calibration position

6.2.2 Mechanical calibration

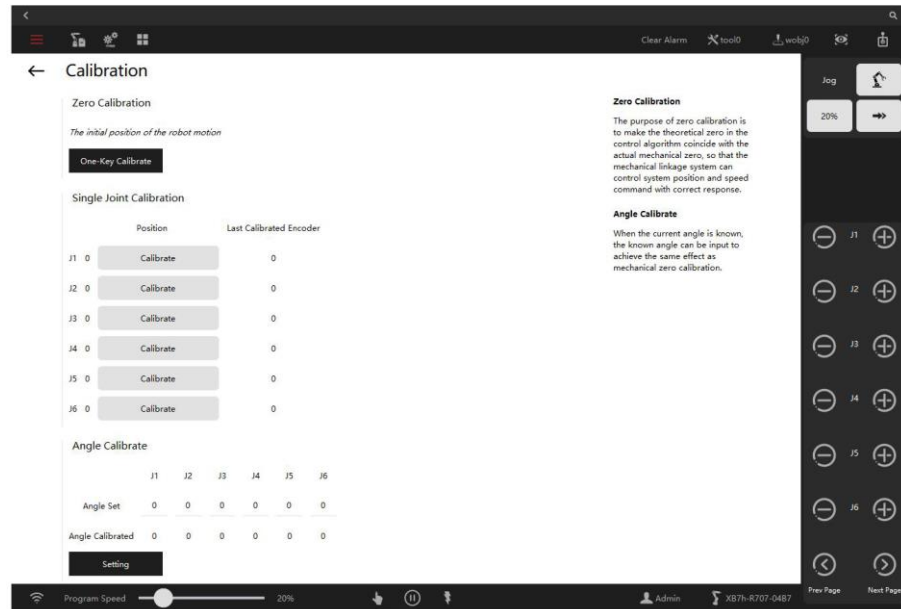


Fig. 33 Mechanical calibration

The mechanical calibration interface is shown in Fig. 33, and the calibration procedures are as follows:

NO.	Operation	Description
1	Log in to the system using an admin-level or above user account and enter the zero calibration interface.	Zero calibration can only be performed in manual mode with no program running. The zero calibration interface is under the "Calibration" category.
2	Jog the robot joints in the single-axis mode, and start the calibration from Axis 1.	Different robots have different zero calibration aids. Refer to the instruction manual for the mechanical arm body of the robot.
3	When the corresponding axis moves to the zero position, click the "Calibrate" button for the corresponding joint on the HMI and complete the calibration of that joint. After this, you can continue to move the next joint.	Only after the previous joint is calibrated, can you click the "Calibrate" button of the next joint. The joints with coupling relationship need to be calibrated simultaneously.
4	Repeat Step 3 until all robot joints are calibrated.	

**Tips**

Because of the flexibility of the robot joints and linkages, calibrate from low to high axis numbers to achieve higher calibration accuracy.

**Tips**

After the zero calibration, the absolute accuracy of the robot may deviate from that when leaving the factory.

6.3 Zero check

Zero calibration has been completed when robot products are delivered.

See Fig. 34 for the zero pose of the robot. In order to ensure the accuracy of the zero point of the robot, it is recommended to check the zero position after startup or recalibration (The robot can be moved to zero position quickly by using the HMI, see Fig. 35).

If the robot cannot return to the correct zero position, please contact us.

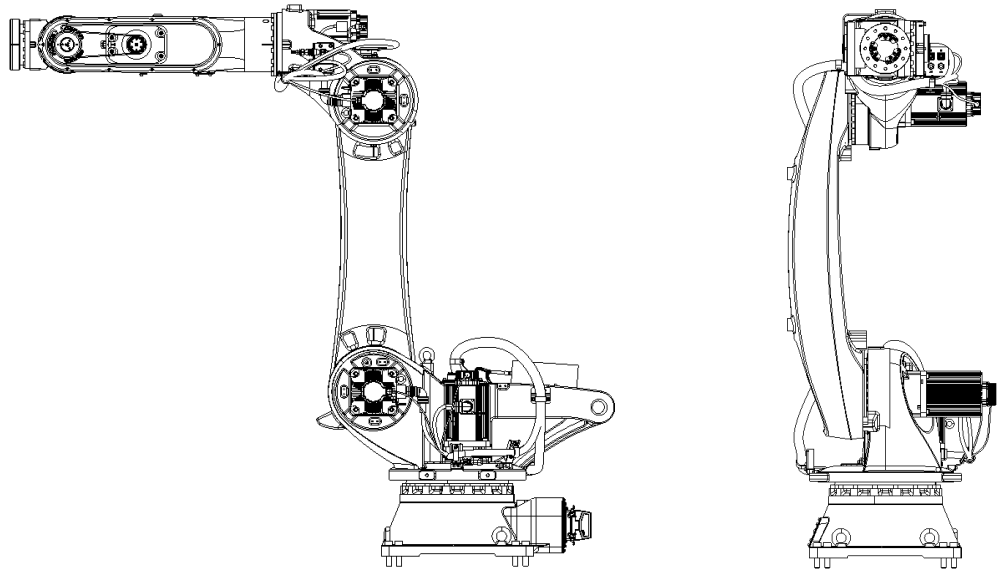


Fig. 34 Zero position of the NB220 robot

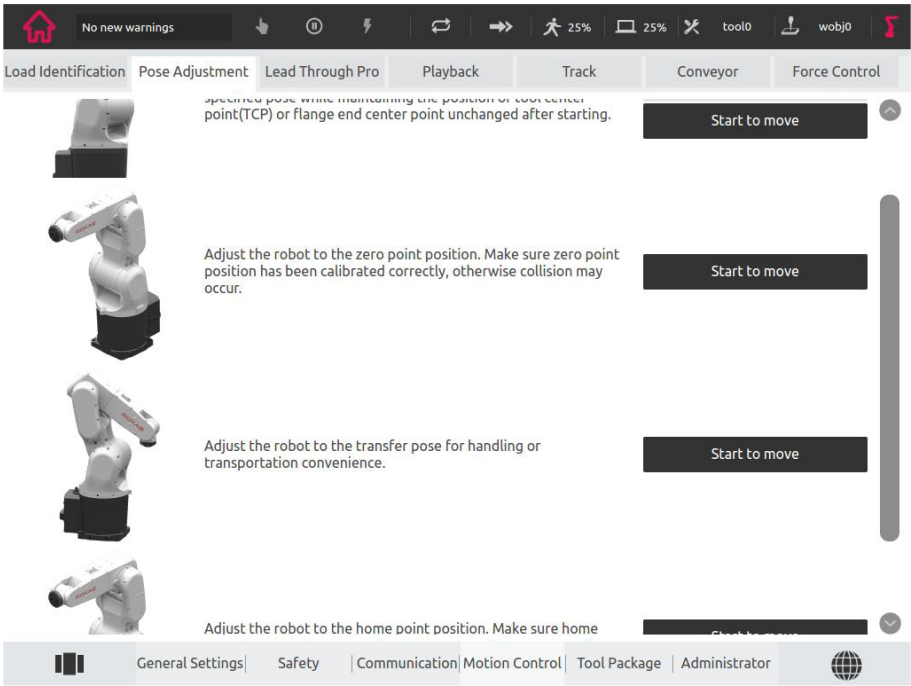

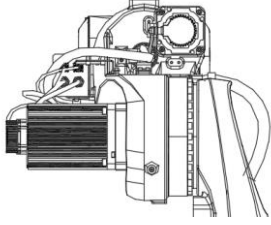


Fig. 35 How to move to zero position



Notes

If the motion range of the mechanism exceeds 360°, and the axis (axis J4) connected to the cable rotates a full circle from the correct zero calibration position to engage, the cable inside the mechanism may get damaged. If the rotational position is unclear due to the large movement of the axis during zero calibration,, check the status of the internal cable, and then perform zero calibration at the correct position. Follow the procedures below to check the cable status:




7 Maintenance

7.1 Introduction


Please carefully read Chapter 7.2, this manual, and other related documents before the maintenance. Perform maintenance after you have fully understood the safe maintenance methods.

7.2 Safety maintenance



Warning

- Please strictly abide by the maintenance procedures and do not disassemble any parts of the robot.
- The maintenance must be carried out by designated professionals.
- If you are not trained, stay away from the robot when it is powered on. Also, do not enter into the working range of the robot. Even if you see that the robot has stopped moving, the powered-on robot may suddenly move and cause serious safety problems.
- Be sure to confirm the action of the robot outside the safety fence after replacing the parts. Otherwise, the robot may perform unexpected actions and cause serious safety problems.
- Before entering normal operation, make sure that the emergency stop switch and the safety fence switch are operating normally. If the robot works in a state where the switch is not operating normally, the safety function cannot be guaranteed in the event of an emergency, and serious injury or damage may occur, which can be extremely dangerous.



Hazard of electric shock

Be sure to turn off the controller and related devices and unplug the power plug before performing the maintenance, replacement and wiring. Failure to do so may result in electric shock or malfunction.

7.3 Maintenance outline

The contents, procedures and plans of the maintenance inspection are described below. Performing the maintenance inspection correctly is critical for preventing product failures and ensuring safety. Please perform the inspection according to the maintenance schedule.

7.3.1 Inspection progress and contents

Inspection items are carried out at five intervals: daily, one month, three months, six months and twelve months. Other items can also be added according to the intervals.

1) With the power OFF

NO.	Item	Position	Interval				
			Daily	1 months	3 months	6 months	12 months
1	Check screws for loosening	Externally visible screws	●				
		Screws around the					●

NO.	Item	Position	Interval				
			Daily	1 months	3 months	6 months	12 months
		axis					
		Screws for motors, reducers, etc.					●
2	Check plugs for loosening	External connector on the robot	●				
		External cables		●			
3	Check for external damage	Robot appearance	●				
		External cables		●			
4	Check belts for loosening	Axis 5/6				●	
5	Encoder battery	Replace the battery if a low-battery error warning appears when the software starts up or once every 1.5 years. (For products with IP67 rating, apply the Tianshan 1527W sealant to the electrical mounting panel during battery replacement).					

2) With the power ON (no action)

NO.	Item	Position	Interval				
			Daily	1 months	3 months	6 months	12 months
1	Shake the cable gently to check for disconnection	External cables				●	●
2	In the enabling state, press each robot with your hand to check for wobbling	Each link of the robot					●

3) With the power ON (with action)

NO.	Item	Position	Interval				
			Daily	1 months	3 months	6 months	12 months
1	Working space confirmation	Each joint					●
2	Check the whole robot for abnormal sound and vibration	Whole robot	●	●	●	●	●
3	Check for change in positioning accuracy and deviation of the stop position from the start position	Whole robot					●

7.3.2 Lubrication

Refill the bevel gears regularly with grease. Make sure to use the specified grease.



Tips

Refilling lubricating oil requires professionals to operate with professional tools! If there is any problem occurred during adjustment, please call us!



Warning

Avoid grease depletion. Once the grease is depleted, abnormal noise may occur and the mechanical transmission components may be damaged, thus affecting the performance and use of the robot;

Be extremely careful when refilling the grease. Once grease enters into your eyes or mouth or adheres to your skin, treat according to the following instructions:

When grease enters into your eyes: Flush your eyes with running water and get medical help;

When grease enters into your mouth: If swallowed, get medical help immediately. Otherwise, wash thoroughly with clean water;

When grease adheres to your skin: Clean it up with water and soap.

7.3.2.1 Oil refill method

It is recommended that customers use a manual pump to refill oil into the robot. The commonly used oil pump is shown in the figure below:



Fig. 36 Grease refill

When using a manual pump, the refill speed should not be too fast (do not exceed 300g/min). The pump pressure is set below 0.03Mpa. To prevent the internal pressure of the reducer from being too high due to the high speed of oil refill, it is best to keep the movement of pressing down at once per second during manual refill.

In addition, when using a manual pump, in order to ensure smooth removal of used oil inside the reducer, it is recommended that after a period of oil refill, stop for a period of time, wait until the outlet does not discharge any grease before continuing to refill oil.



Tips

Open the oil outlet before refilling oil. Refilling too fast will cause the instantaneous internal pressure of reducer to go high. Grease with high pressure may cause damage to the oil seal, then the grease may enter the motor and cause oil leakage to the module.



Warning

The robot should run for 10 to 20 minutes before checking the oil level.
After the robot starts running, the temperature of the motor and gear is very high. Be careful not to get burnt.
Turn off all power, hydraulic and air sources.
Because the temperature of oil in the gearbox is very high, the pressure inside may increase. When opening the plug, the oil inside may be ejected. Therefore, the operator must wear protective glasses and gloves when replacing or discharging lubricating oil!

7.3.2.2 Reducer lubrication

In order to exert the performance of the robot adequately, use the specified type of grease at a certain amount at the corresponding position. Apply grease in each axis as shown in the following table:

No.	Grease Model
A1	VIGOGREASE REO
A2	
A3	
A4	
A5	
A6	



Tips

The robot has been filled with a specified amount of grease when leaving the factory. Do not mix with other greases, otherwise, the reducer may break down after it is used for a period of time.

7.3.2.3 A1 Lubrication

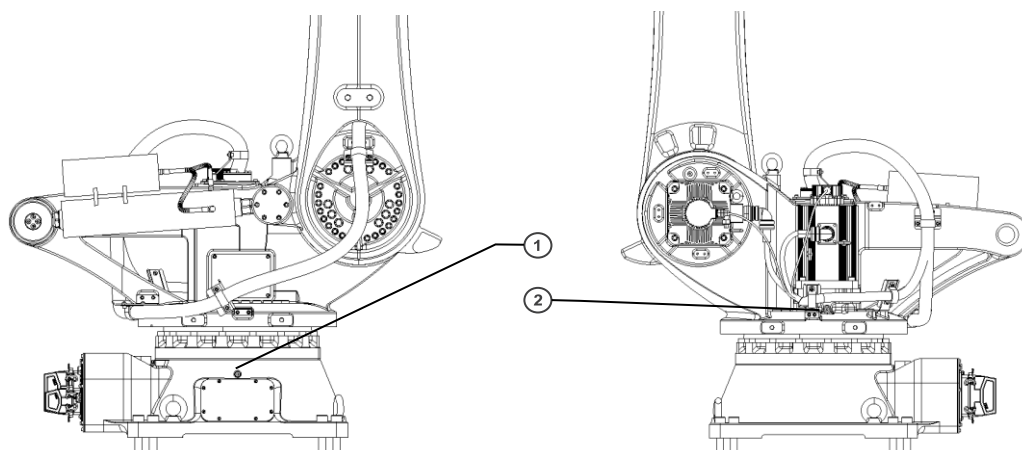


Fig. 37 A1 grease refill

	Description
1	Axis 1 oil inlet
2	Axis 1 oil outlet

Grease replenishment and replacement steps for the Axis 1 reducer:

- 1) Adjust all axes to the zero position;
- 2) Remove plugs from the oil inlet and oil outlet for Axis 1;
- 3) Install the G1/8 nozzle at the oil inlet;
- 4) Refill oil from the oil inlet with an oil gun. The refill speed should not exceed 300g/min, until the old oil is completely emptied and the new oil flows out. When the grease replacement is completed, install the plug at the oil inlet, and apply the Three Bond 1215 sealant to the thread;
- 5) Before installing the plug at the oil outlet, run Axis 1 for 20min at the velocity of V1000 50% in the motion range of $\pm 80^\circ$ to discharge redundant grease and gas;
- 6) Wipe the redundant grease out of oil outlet with a cloth, and install the plug at the oil outlet. Apply the Three Bond 1215 sealant to the screw thread of the plug.

7.3.2.4 A2 Lubrication

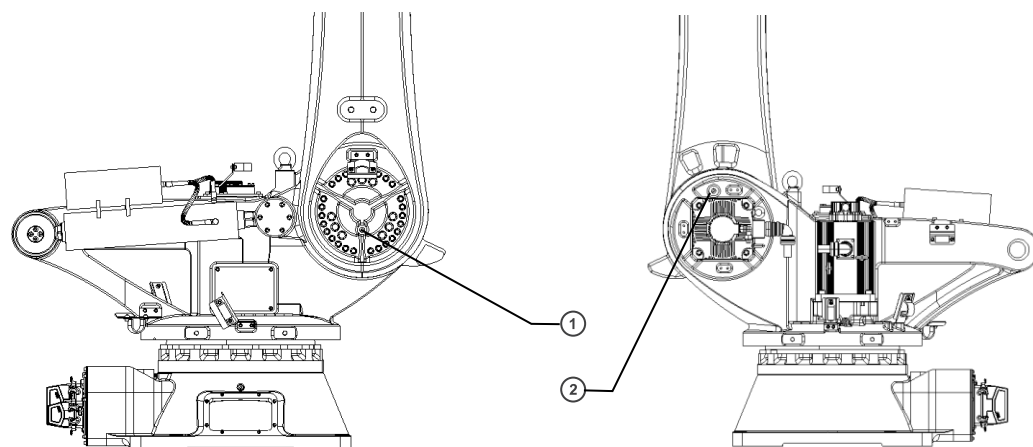


Fig. 38 A2 grease refill

	Description
1	Axis 2 oil inlet
2	Axis 2 oil outlet

Grease replenishment and replacement steps for the Axis 2 reducer:

- 1) Adjust all axes to the zero position;
- 2) Remove plugs from the oil inlet and oil outlet for the Axis 2;
- 3) Install the G1/8 nozzle at the oil inlet;
- 4) Refill oil from the oil inlet with an oil gun. The refill speed should not exceed 300g/min, until the old oil is completely emptied and the new oil flows out. When the grease replacement is completed, install the plug at the oil inlet, and apply the Three Bond 1215 sealant to the thread;
- 5) Before installing the plug at the oil outlet, run Axis 2 for 20min at the velocity of V1000 50% in the motion range of $\pm 90^\circ$ to discharge redundant grease and gas;
- 6) Wipe the redundant grease out of oil outlet with a cloth, and install the plug at the oil outlet. Apply the Three Bond 1215 sealant to the screw thread of the plug.

7.3.2.5 A3 Lubrication

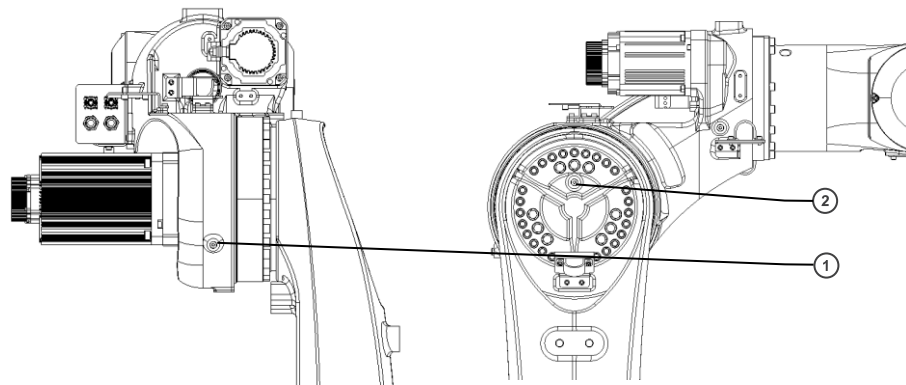


Fig. 39 A3 grease refill

	Description
1	Axis 3 oil inlet
2	Axis 3 oil outlet

Grease replenishment and replacement steps for the Axis 3 reducer:

- 1) Adjust Axis 2 to the -60° position, Axis 3 to the 60° position, and all other axes to the zero position;
- 2) Remove plugs from the oil inlet and oil outlet for Axis 3;
- 3) Install the G1/8 nozzle at the oil inlet;
- 4) Refill oil from the oil inlet with an oil gun. The refill speed should not exceed 300g/min, until the old oil is completely emptied and the new oil flows out. When the grease replacement is completed, install the plug at the oil inlet, and apply the Three Bond 1215 sealant to the thread;
- 5) Before installing the plug at the oil outlet, run Axis 3 for 20min at the velocity

of V1000 50% in the motion range of $\pm 70^\circ$ to discharge redundant grease and gas;

6) Wipe the redundant grease out of oil outlet with a cloth, and install the plug at the oil outlet. Apply the Three Bond 1215 sealant to the screw thread of the plug.

7.3.2.6 A4 Lubrication

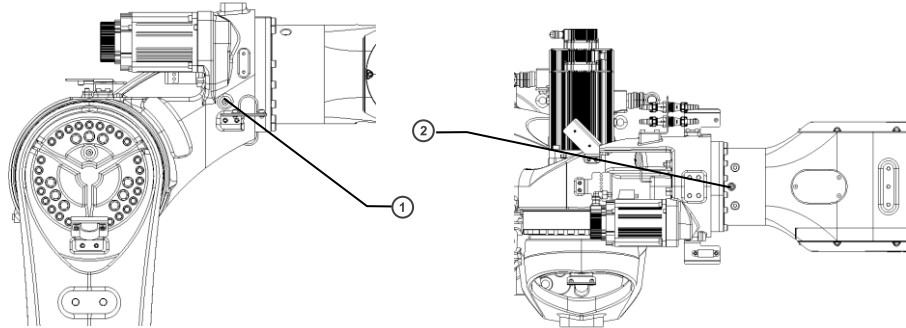


Fig. 40 A4 grease refill

	Description
1	Axis 4 oil inlet
2	Axis 4 oil outlet

Grease replenishment and replacement steps for the Axis 4 reducer

- 1) Adjust all axes to the zero position;
- 2) Remove plugs from the oil inlet and oil outlet for Axis 4;
- 3) Install the G1/8 nozzle at the oil inlet;
- 4) Refill oil from the oil inlet with an oil gun. The refill speed should not exceed 300g/min, until the old oil is completely emptied and the new oil flows out. When the grease replacement is completed, install the plug at the oil inlet, and apply the Three Bond 1215 sealant to the thread;
- 5) Before installing the plug at the oil outlet, run Axis 4 for 20min at the velocity of V1000 50% in the motion range of $\pm 90^\circ$ to discharge redundant grease and gas;
- 6) Wipe the redundant grease out of oil outlet with a cloth, and install the plug at the oil outlet. Apply the Three Bond 1215 sealant to the screw thread of the plug.

7.3.2.7 A5/A6 Lubrication

Refill the bevel gears regularly with grease. Make sure to use the specified grease.



Warning

Avoid grease depletion. Once the grease is depleted, abnormal noise may occur and the mechanical transmission components may be damaged, thus affecting the performance and use of the robot;

Be extremely careful when refilling the grease. Once grease gets into your eyes or mouth or adheres to your skin, refer to the following instructions:

when grease gets into your eyes: Flush your eyes with running water and get

<p>medical help;</p> <p>When grease gets into your mouth: If swallowed, get medical help immediately.</p> <p>Otherwise, wash thoroughly with clean water;</p> <p>When grease adheres to your skin: Clean it up with water and soap..</p>			
	Name	Quantity	Note
Maintenance material	VIGOGREASE REO	Appropriate	The amount depends on the situation
Tool	Hex wrench	1	For removal
	Rag	1	For wiping excess grease
	Thread sealant	Appropriate	

Procedures for refilling grease for NB220 wrists:

- 1) Adjust the wrist to a horizontal position and power off the robot;
- 2) Unscrew the hex shoulder bolt SPN-1-H with a hex wrench;
- 3) Clean the thread to prevent impurities from falling into the gearbox;
- 4) Refill an appropriate amount of grease into the wrist;
- 5) Before installing the plug at the oil outlet, run Axis 5/6 for 20 min at the velocity of V1000 50% in the motion range of $\pm 90^\circ$ to discharge redundant grease and gas;
- 6) Apply an appropriate amount of thread sealant to the hex shoulder bolt SPN-1-H and screw it back with a tightening torque of 6 Nm.

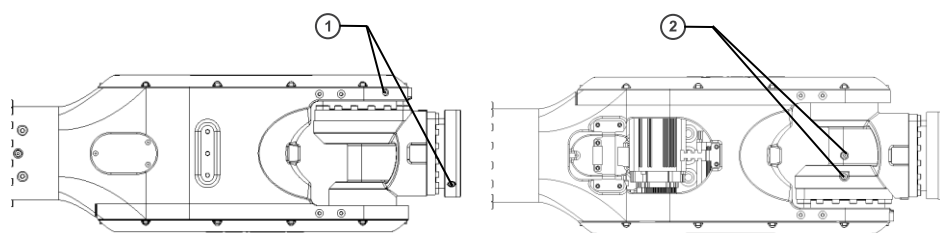


Fig. 41 Grease refill

No.	Name
1	Oil filling port
2	Oil outlet

7.3.3 Fastening of socket head cap screws

Use socket head cap screws (hereinafter referred to as "screws", in Grade 12.9) at the positions requiring connection strength. When assembling, tighten the screws as per the

tightening torque shown below. Unless otherwise specified, when tightening the screws again in the operations described in this manual, use a torque wrench based on the tightening torques that are shown in the table below.

NO.	Socket head cap screw	Torque (Nm)
1	M3	2
2	M4	4
3	M5	9
4	M6	15
5	M8	35
6	M10	70
7	M12	125
8	M14	205
9	M16	319
10	M20	493

For the torque of the set screws used for the pulley, refer to the following table:

NO.	Socket flat head set screw	Torque (Nm)
1	M4	2
2	M5	3.9

It is recommended to fix the screws arranged on the circumference in diagonal order as shown in the figure below. When fixing, do not tighten the screws one at a time, but tightening in 2~3 times by using a hex wrench, and then tighten the screws by following the tightening torques listed in the table above using a torque wrench.

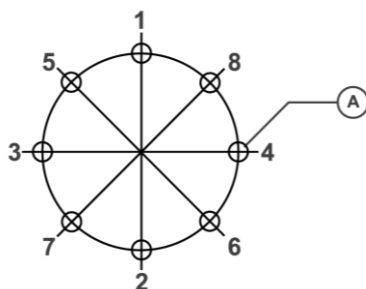


Fig. 42 Screw tightening diagram

No.	Description
A	Hole

7.3.4 Battery replacement

7.3.4.1 Safety risks with battery

Under normal service conditions, the motor materials and liquid electrolyte in the battery will not be exposed to the outside as long as the battery remains intact. Only when the battery is

used improperly under mechanical, thermal and electrical influences, safety risks may occur. These situations will activate the safety valve and/or damage the battery container. Based on the specific environment, this may result in electrolyte leakage, reaction between the electrode material and vapor/water or battery leakage, explosion or fire.



Warning

Pay sufficient attention to the use of battery. Avoid the wrong usages described below, which may lead to heating, liquid leakage, explosion or fire.

Wrong usages include: attempting to charge, compressed deformation, disassembling, short circuit, improper battery connection, heating, placing in fire, soldering battery terminals and forced discharge.

For disposal of abandoned battery, refer to the relevant laws and regulations of your country/region, or consult a professional company for disposal. Note that even used batteries can cause danger due to short circuit if they come into contact with other metals or battery terminals.

7.3.4.2 Replacing the battery

Status confirmation:

Only when the robot stays stationary and the power is OFF can you replace the battery. Check the status before operation.



Warning

A mechanical zero inspection should be performed upon the completion of battery replacement on the robot in any status.

Preparation of tools: Prepare replacement tools according to the table below.

NO.	Tool	Specification	Quantity
1	Side-cutting pliers	—	1
2	Socket head wrench	3	1
3	Nylon tie	3X100mm	2

Replacement procedures:

Step 1: Remove the external cables connected to all electrical interfaces on the robot base;



Warning

During the battery replacement, take necessary precautions to prevent others from switching on the system power supply.

Step 2: Remove the fixing screws 6-M4X16 from the electrical installation board of the base and pull out the electrical installation board;

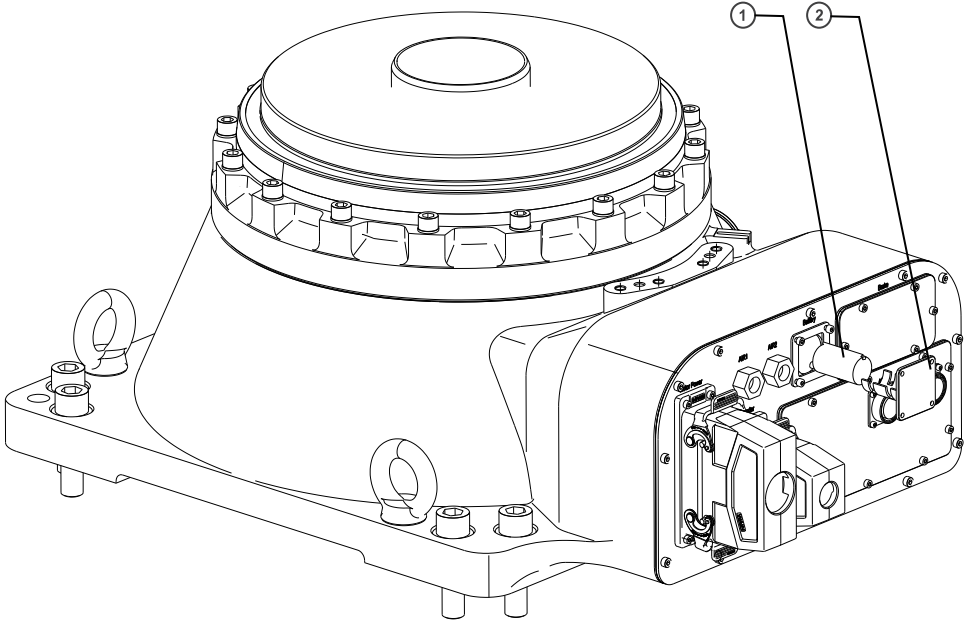


Fig. 43 Replacing the battery

No.	Name	Specification	Quantity
1	Battery pack		1
2	Socket head cap screw	M4X10	4

Step 3: Cut off the ties that fix the old battery pack;

Step 4: Bundle the new battery onto the cable board with ties;

Step 5: Connect the fitting of the new battery to the idle black connector;

Step 6: Remove the old battery;

Step 7: Install the electrical installation board back.



Tips

When the zero point is lost due to failure to follow the above procedures, refer to 6.2. to carry out the zero calibration.

7.3.5 Maintenance of timing belts



Warning

The adjustment and maintenance of timing belts must be carried out by professionals using professional tools. After replacement, conduct a zero calibration on the robot. If you have any problem during the adjustment, please contact ROKAE.

Axes 5 and 6 of the robot are all driven by timing belts. If they become loosened, they may cause abnormal sound, accuracy decrease and other failures. Therefore, it is required to check the timing belts every 6 months to prevent them from being loosened and causing failure.

7.3.5.1 Maintenance of the A5 timing belts

Remove the cover plate on the left side of the upper arm and measure the belt tension with a belt tension meter. The standard tension force of the timing belt is 270-300N. If the measurement result is beyond this range, adjust it by following the steps below:

- Loosen the flange fixing screws (a total of three, loosen them to an extent to which the pulley can move freely);
- Tighten the pulley by using a spring scale, and adjust the tension to the specified value;
- Tighten the flange fixing screws (for the tightening torque, see 7.3.3);
- Install the side cover of the upper arm.

If the timing belt or sealing gasket is found to be damaged, replace it in time. After replacement, perform another zero calibration on the robot.

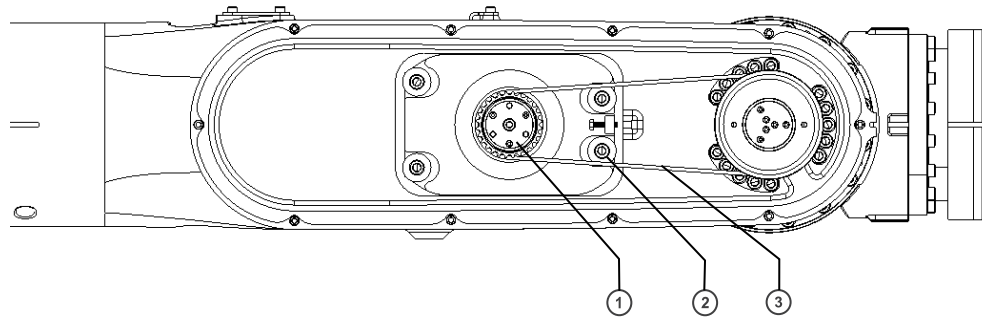


Fig. 44 Maintenance of A5 timing belts

NO.	Name	Specification	Quantity
1	Pulley P40-S8M-15	12020300123	1
	Pulley P42-S8M-15	12020101544	1
2	Screws	16010101060	4
	Washer	16030100206	4
3	Timing belt	14040300255	1

7.3.5.2 Maintenance of the A6 timing belts

Remove the cover plate on the right side of the upper arm and measure the belt tension with a belt tension meter. The standard tension force of the timing belt is 270-300N. If the measurement result is beyond this range, adjust it by following the steps below:

- Loosen the flange fixing screws (a total of three, loosen them to an extent to which the pulley can move freely);
- Tighten the pulley by using a spring scale, and adjust the tension to the specified value;
- Tighten the flange fixing screws (for the tightening torque, see 7.3.3);
- Install the side cover of the upper arm.

If the timing belt or sealing gasket is found to be damaged, replace it in time. After replacement, perform another zero calibration on the robot.

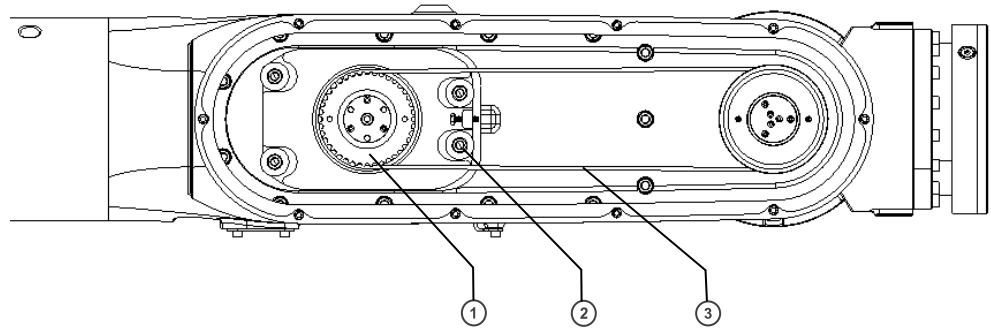


Fig. 45 Maintenance of timing belts

NO.	Name	Specification	Quantity
1	Pulley P28-S8M-15	12020300123	1
	Pulley P42-S8M-15	12020101544	1
2	Screws	16010101060	4
	Washer	16030100206	4
3	Timing belt	14040300255	1

7.3.6 Maintenance of Balancer



Warning

The maintenance of the balancer shall be operated by professional tools in strict accordance with the following specifications. If there is any problem in the adjustment, please call our company..

7.3.6.1 Pressure relief of balancer



Warning

When the balancer is relieved, the improper operation is easy to cause force rebound, high pressure gas ejection, hydraulic oil splashing and other problems. Accidental operation may lead to serious injury, death, or property loss.

In the work, must be conducted by professional training, must be careful in the operation, if there are problems or uncertain operation, please immediately stop the current operation, and call the company.

1) Status confirmation:

- Remove the load at the end of the robot, and the balance cylinder can not be relieved before removal.
- Run the robot after removing the load to the "zero position", referring to Figure 34 in Section 6.3.
- Only when the robot is at the zero point attitude, the balance cylinder can perform pressure relief operation.
- Again confirm that the robot is in the no-load, zero point attitude, and then take the emergency stop, can be directly power off if necessary, to ensure that the robot will not run accidentally when the pressure relief work.

- Be sure to check this status before the operation.



Warning

When the robot is the pressure relief operation of the balancer, make sure that the end of the robot is not loaded, the robot is in zero attitude, and the robot is in emergency stop / power off state.

2) Tool preparation:

Prepare the pressure relief tools according to the table below

No.	Tool	Description	Quantity
1	Single head valve spoon	126011	1
2	Inner hexagon wrench kit	one's set way	1
3	Sings with sufficient bearing capacity	Weight=37 kg	1

3) Pressure relief steps:

Step 1: Remove the oil plug at the rear end of the balancer.



Warning

Please keep the removed plug properly, which can only be dedicated and can not be replaced by other plugs. Otherwise there is a danger of high pressure gas leakage.

Step 2: Put the valve core wrench into the air inlet, and turn the valve core to rotate;

Step 3: Slowly twist the valve core until it stops when the gas is released;



Warning

When twisting the valve core wrench, operate slowly and stay away from the outlet to prevent oil splash; When gas starts to release, stop turning the valve core.

Step 4: wait for the gas release for 4~6 minutes, when the gas release amount becomes small, and then properly loosen the valve core;



Warning

In the process of deflation, personnel must operate carefully and always pay attention to the state of gas pressure relief. If there is no pressure relief sound, please further loosen the valve core.

Step 5: Repeat Step 4 until the valve core is completely loose

Step 6: Remove the valve core and screw on the oil plug.



Warning

After removing the valve core, please keep the material properly. If it is lost, please

contact the company for a new replacement. Do not use other products without authorization.

7.3.6.2 The filling pressure of the balancer



Warning

Due to the high pressure gas filling, improper operation is easy to detonate the cylinder, high pressure gas injection, high pressure oil splashing and other problems, accidental operation may lead to serious injury, death or property loss.

In the work, all must be trained by professionals, must be careful in the operation, if there are problems or uncertain operation, please immediately stop the current operation, and call the company.

1) Status confirmation:

- Remove the load at the end of the robot, and the balance cylinder can not be relieved before removal.
- Run the robot after removing the load to the "zero position", referring to Figure 34 in Section 6.3.
- Only when the robot is at the zero point attitude, the balance cylinder can perform pressure relief operation.
- Again confirm that the robot is in the no-load, zero point attitude, and then take the emergency stop, can be directly power off if necessary, to ensure that the robot will not run accidentally when the pressure relief work.
- Be sure to check this status before the operation.



Warning

When the robot is the pressure relief operation of the balancer, make sure that the end of the robot is not loaded, the robot is in zero attitude, and the robot is in emergency stop / power off state.

2) Tool preparation:

Prepare the pressure relief tools according to the table below

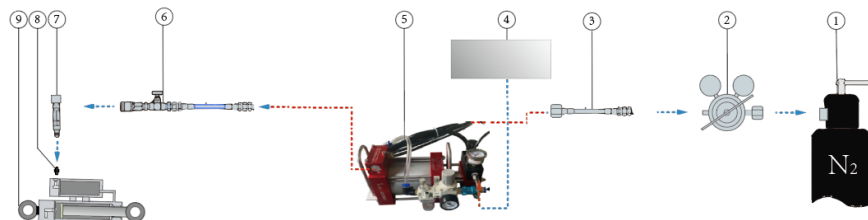


Fig. 46 pressure relief tools

No.	Name	Specification	Quantity
1	Nitrogen	40L-15Mpa-99.99%	1
2	compression release gauge	G5/8-25MPa-M16x1.5	1
3	Dual-joint trachea	Black, 3m	1

4	Air supply	Air compressor with compressed air	1
5	Gas booster unit	DTC40	1
6	Inflatable switch		1
7	High-Voltage transfer	G1/8	1
8	Valves inside		1
9	Balancer	LS220-S03 DPHL3000-300	1

3) Pressure relief steps:

Step1: Use the socket screw with 5mm plug the inflation socket and remove the plug;



Warning

Please keep the removed plug properly, which can only be dedicated and can not be replaced by other plugs. Otherwise there is a danger of high pressure gas leakage.

Step2: Extend the valve core wrench into the inflatable port, check the tightening state of the valve core. If not, install a valve core and tighten it (install installed valve core);



Warning

Do not too hard to tighten it for which is very easy to damage the valve core (standard torque is 0.5 Nm)

Step3: Check whether the left tooth nut is tightened: lock it with a crescent hook wrench, lock it counterclockwise, and loosen it clockwise;



Warning

Before locking the nut, make sure that the balancer body does not interfere with the robot body

Step4: Connect the inflatable device as shown in Figure 43;

Step 5: Make sure that the unloading valve is closed and that the inflation switch is closed, and then slowly open the nitrogen bottle with the live wrench, check the pressure representation on the booster unit, and close the nitrogen bottle opening after the number appears;



Warning

Do not twist the wrong switch of Nitrogen bottle and the direction for tightening

is the clockwise. For the release and tightening direction of the unloading valve on the booster pump, please refer to the identification on the equipment.

Step 6: Turn on the inflation switch to ensure the smooth nitrogen in the pipeline, and turn off the inflation switch after deflation.

Step 7: Lock the quick charging head (G1 / 8) to the inflation port, tighten it with a active wrench, then plug the inflation switch into the quick charging head, tighten the inflation switch clockwise to confirm that the switch is locked;

Step 8: Open the filling valve slightly, then open the nitrogen bottle switch, and check the number change of the pressure gauge on the booster pump. After reaching the balance cylinder demand value, close the nitrogen bottle switch;

Step 9: First close the nitrogen bottle switch, tighten (close) the filling valve switch, open the pressure relief valve to discharge the high pressure gas, unplug the filling valve, and remove the quick charging head;

Step 10: Add hydraulic oil at the air inlet to see if there is any air leakage;

Step 11: Turn on the inflation port plug screw.



Warning

After the filling is completed, check whether the pressure value of the gas meter is the rated pressure value (refer to the pressure value of the balance cylinder body) and wait for 5 minutes. If the number remains at the rated value, complete the gas filling process.

7.4 Cleaning

In order to ensure long-term stable operation of the robot, clean the robot regularly, i.e. every 960 hours or 3 months of operation (whichever comes first), by following the process below:

- Adjust the robot to the calibration state;
- Turn off the power, hydraulic and air sources of the robot;
- Clean the robot using a vacuum cleaner or wipe it with a rag;
- Power up the robot after confirming that all safety conditions are met.



Warning

Do not flush the robot with water;
Do not clean the robot with compressed air;
Do not clean the robot with chemical agent such as solvent and reagent;
Do not clean the robot in case of incomplete robot appearance;

Do not clean the robot with the power on.

7.5 Confirmation after maintenance

Each time after performing maintenance operation on the robot, you should always confirm the robot status by following the procedures below:

NO.	Item
1	Whether the robot appearance is intact
2	Whether the robot is fixed securely
3	Whether the robot cable is correctly connected
4	Estimate whether the working environment has an impact on the robot's working space
5	Whether the robot is at zero

Only switch on the power supply of the robot when all the basic items above are inspected and confirmed.

7.6 Maintenance Part List

Name	Position	Code	Remarks	Reference section
Timing belt	A5	14040300106	B=9mm	7.3.5.1
	A6	14040300105	B=9mm	7.3.5.2
Battery pack	Base electrical installation board	15020301005/15070401332	Battery pack / Encoder battery component	7.3.4
Grease	Wrist	19010100009	96 grease (appropriate amount)	7.3.2

8 Common Failures

8.1 Introduction

Robot failures are often caused by a combination of multiple factors. The real causes of the failure should be identified meticulously. Improper handling methods will cause the failure to further deteriorate and may also affect the analysis of the causes.

8.2 Analysis of the failure causes and countermeasures

Possible failures of the robot are summarized in the table below. For those circumstances not mentioned in the list and for which causes cannot be identified, please contact ROKAE promptly.

Failure	Description	Possible causes	Solution
Vibration and abnormal noise	During moving, the robot floats against the fixing base, fixing plate and backing plate.	1) The fixing screw of the robot becomes loose; 2) The flatness of the fixing plane is insufficient; 3) There are foreign objects on the fixing plane.	1) Tighten the fixing screws with a torque wrench. Refer to 7.3.2.3 for the recommended torque range; 2) Trim the flatness of the fixing base; 3) Check for foreign objects; 4) Contact ROKAE for other circumstances.
	During moving, vibration occurs in a certain pose, especially upon acceleration and deceleration.	1) The load of the robot exceeds the limit; 2) The action program of the robot is too intense.	1) Confirm whether the load is reasonable; 2) Alleviate the vibration by adjusting the velocity value and acceleration value of the program or by changing the action program; 3) Contact ROKAE for other circumstances.
	Vibration occurs when restoring motion after a collision; vibration occurs in case of prolonged motion under overload.	The robot's internal mechanical transmission system may be damaged due to collision or overload (damage	It is recommended to identify the abnormal position through single-axis motion and then contact ROKAE.

Failure	Description	Possible causes	Solution
		to reducers, gears, bearings, etc.).	
	Vibration and abnormal sound occur at joints during normal use but without maintenance for a long time.	The reducers, gears and bearings may suffer from fatigue and damage for lack of grease for a long time.	Contact ROKAE if you need to replace the grease.
	Vibration that cannot be analyzed from the mechanical perspective	<ol style="list-style-type: none"> 1) Motor failure may lead to abnormal vibration of the robot; 2) The system may not be able to send the motor position to the control end due to encoder failure, thus resulting in abnormal vibration of the robot; 3) The abnormal vibration of the robot may be caused by signal transmission error due to damage or breakage of internal cables of the robot or loosening of the cable fitting. 	Contact ROKAE for operations involving replacement of motors and cables.
Grease leakage	Grease leakage observed from the exterior	<ol style="list-style-type: none"> 1) May be caused by improper sealing of reducer at the joint; 2) May be caused by wear of oil seal lip by impurities in extreme conditions; 3) May be caused by improper sealing 	Contact ROKAE for operations involving replacement of oil seal.

Failure	Description	Possible causes	Solution
		between the cover plate and arm body.	
Robot drooping	Falling of axes due to brake failure; Falling of axes after brake engagement.	The brake drive may be damaged and the brake cannot engage when the power is on, resulting in brake failure; The brake may be worn and the friction disc fails.	Contact ROKAE for operations involving replacement of brakes or motors.
Position offset	1) The taught position of the robot and the actual action are inconsistent; 2) The repositioning accuracy of the robot is abnormal.	1) When the repositioning accuracy is unstable, the offset may be caused by mechanical system abnormality and screw loosening; 2) When the repositioning accuracy is stable and the offset value is fixed, the offset may be caused by sliding of the reference plane, joint reducer and casting due to collision or overload; 3) The offset may be caused by motor encoder failure.	Identify the cause by analyzing the repositioning accuracy and contact ROKAE.
	Position offset after parameter changes	The origin may be lost due to parameter changes.	Perform the zero calibration again.

Revision

Version	Date	Content
A	2023/11/26	Initial version

ROKAE



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