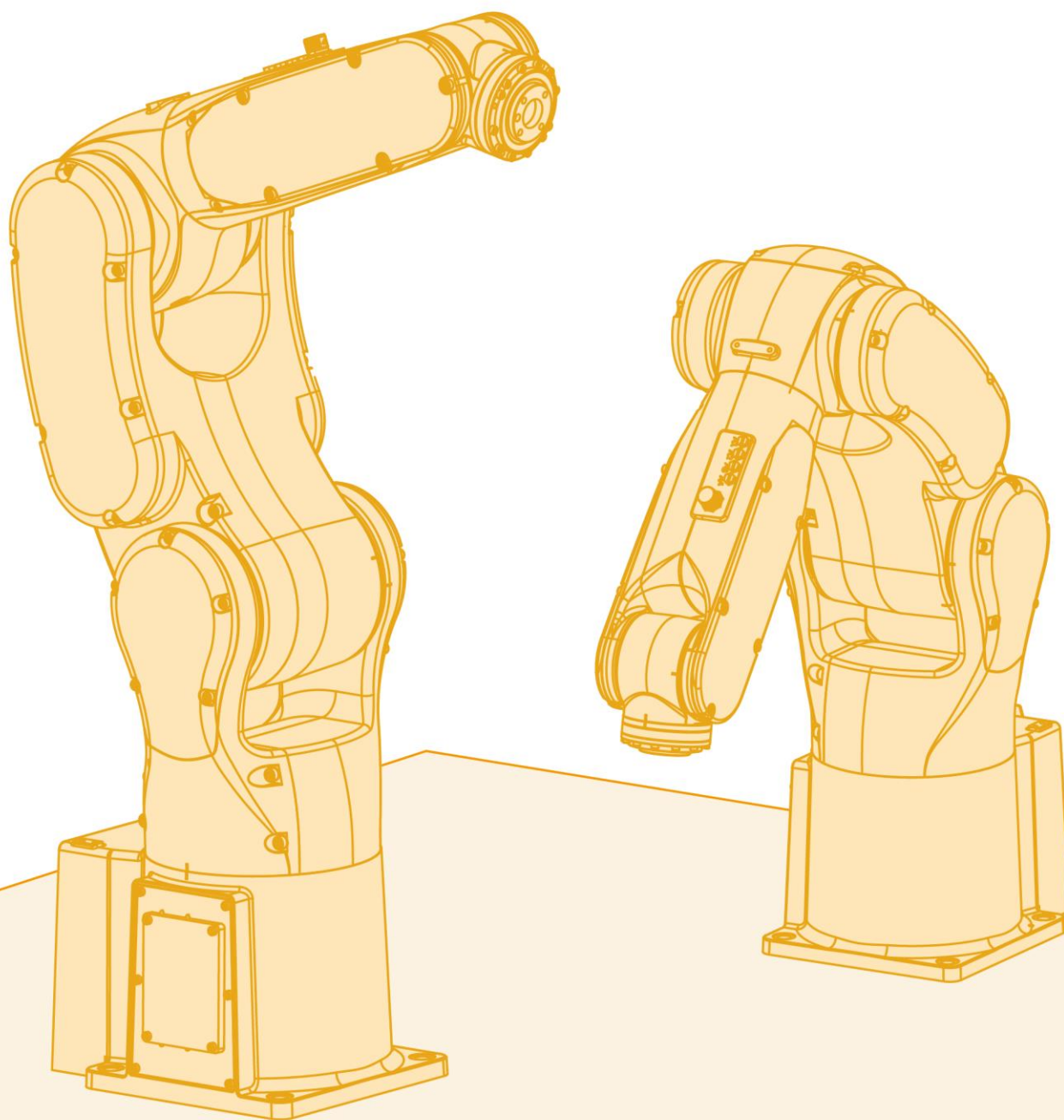


# AIR4-560A Operation Manual

V2.0.9





# Foreword

---

## About this manual

This manual is for technicians to install, use, and use the AIR4-560A industrial robot quickly, correctly, and safely, to be familiar with the relevant precautions, and to perform regular routine maintenance work on the manipulator.

## Prerequisites

Before operating the robot, be sure to read the relevant safety instructions and operation instructions of the product carefully. Users must understand the safety knowledge and basic operation knowledge before using the robot.

Please read the following documents when necessary:

- "inCube20 Control Cabinet Manual"
- "AIR-TP Teach Pendant Operation Manual"
- "ARL Programming Manual"




## Target groups


- Operators
- Product technicians
- Technical service personnel
- Robot teachers

## Meaning of common signs

The signs and their meanings in this manual are detailed in Table 1.

Table 1 Signs used in this manual

| Sign   | Meaning  |
|--|--|
| <br>Danger  | Failure to follow the instructions may result in an accident causing the severe or fatal injury or the great losses of property. |
| <br>Warning | Failure to follow the instructions may result in an accident causing the severe or fatal injury or the great losses of property. |
| <br>Caution | Prompt for the environmental conditions and important things or shortcuts you shall pay attention to                             |

| Sign  | Meaning  |
|---|--|
| <br>Prompt | Prompt for additional literature and instructions for additional information or more detailed operating instructions |

### Manual description

The contents of this manual are subject to supplementation and modification. Please visit "Download Center" on the website regularly to obtain the latest version of this manual in a timely manner.

Website URL: <http://robot.peitian.com/>

### Revision history

The revision history contains the instructions for each document update. The latest version of the document contains updates to all previous versions of the document.

Table 2 Signs used in this manual

| Version | Publication date | Modification description  |
|---------|------------------|---|
| V2.0.1  | 2020.08.01       | Modify the range of motion of 3 axes  |
| V2.0.2  | 2020.08.26       | Modify the range of motion of 5 axes  |
| V2.0.3  | 2020.09.21       | Corrected diagram of the position of the center of mass of the wrist load of the AIR4-560A  |
| V2.0.4  | 2021.01.20       | 1. The document code is changed to "UM-P0531000024-001"<br>2. Replace "Figure 3-3 AIR4-560A manipulator base interface dimensions". The original picture has an incorrect perspective and the positioning pin and grounding head under the base cannot be seen. |
| V2.0.5  | 2021.08.21       | Fixed known bugs.   |
| V2.0.6  | 2021.11.26       | Added "load inertia moment calculation method"  |
| V2.0.7  | 2022.03.11       | Added "Heat engine related instructions"  |
| V2.0.8  | 2022.05.11       | Fixed known bugs.   |
| V2.0.9  | 2023.03.22       | Add "Grounding instructions"  |

## Manual Number and Version

The manual-related information is shown in Table 3.

Table 3 Document-related information

|                  |                              |
|------------------|------------------------------|
| Document name    | "AIR4-560A Operation Manual" |
| Document number  | UM-P0531000024-001           |
| Document version | V2.0.9                       |

## Declaration of applicable with product standards

The requirements for industrial robot system design are detailed in Table 4.

Table 4 Declaration of applicable safety standards

| Standard       | Description   | Version |
|----------------|---|---------|
| 2006/42/EC     | Machinery directive :<br>Machinery directive 2006/42/EC (new version) issued by European Parliament and Council on May 17, 2006 to modify 95/16/EC  | 2006    |
| 2014/30/EU     | Electromagnetic compatibility directive:<br>2014/30/EU directive issued by European Parliament and Council on February 26, 2014 to balance the electromagnetic compatibility regulations of member states   | 2014    |
| 2014/68/EU     | Pressure facility directive:<br>Electromagnetic compatibility directive:<br>2014/68/EU directive issued by European Parliament and Council on May 15, 2014 to balance the pressure facility regulations of member states<br>(It is only suitable for the robot with hydraulic balance weight) | 2014    |
| ISO 13850      | Safety of machinery:<br>Emergency stop function - Principles for design   | 2015    |
| ISO 13849-1    | Safety of machinery:<br>Safety-related parts of control systems - Part 1: General principles for design   | 2015    |
| ISO 12100      | Safety of machinery:<br>General principles for design - Risk assessment and risk reduction  | 2010    |
| ISO 10218-1    | Robots and robotic devices - Safety requirements for industrial robots :<br>Part 1: Robots<br>(Prompt: Information is consistent with ANSI/RIAR.15.06-2012, Part 1)   | 2011    |
| 61000-6-2      | Electromagnetic compatibility (EMC):<br>Part 6-2: Generic standards - Immunity for industrial environments  | 2005    |
| 61000-6-4 + A1 | Electromagnetic compatibility (EMC):<br>Part 6-4: Generic standards - Emission standard for industrial  | 2011    |

| Standard     | Description  | Version |
|--------------|--|---------|
|              | environments   |         |
| 60204-1 + A1 | Safety of machinery:<br>Electrical equipment of machines - Part 1: General requirements  | 2009    |
| IEC 60529    | IP rating provided by enclosures (IP Code):<br>This standard applies to the IP rating for the electrical equipment with enclosures and the rated voltage exceeding 72.5kv. | 2001    |

## General safety description

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Thank you for purchasing our manipulator. This description is required for the safe use of the manipulator. before using the operator, please read the manual carefully and use the manipulator correctly on the premise of understanding it.

For the detailed functions of the manipulator, please fully understand its specifications through the relevant instructions.

### Safety considerations

In general, the manipulator cannot be operated by a single operation, and only install the end effector, and the frame functions as the peripheral equipment and the system to perform the operation.

When considering its security, the manipulator should not be considered independently, but should be considered in the system environment.

When using the manipulator, be sure to take corresponding measures to the safety fence.

### WARNING, CAUTION AND PROMPTS.

This specification includes matters needing attention to ensure the personal safety of operators and prevent damage to operators. According to their safety importance, they are described as "warning" and "caution" in this paper, and the supplementary instructions are described as "prompts".

Before using the operator, the user must read these "warnings ", "cautions" and "prompts ".



In the case of an incorrect operation, it is possible to cause death or serious injury to the operator or other operator.




If the operation is wrong, it may cause the operator or other operator to slightly injure or damage the equipment.


### General considerations




- When connecting or disconnecting related peripheral devices (such as safety fences, etc.) and various signals of the manipulator , be sure to confirm that the manipulator is in a stopped state to avoid incorrect connections.
- Do not use the operator in the situation shown below. Otherwise, it will not only have a negative impact on operators and peripherals, but also cause casualties.


|   |   |
|---|---|
|   | <ul style="list-style-type: none"> <li>● Used in flammable environments.</li> <li>● Used in explosive environments.</li> <li>● Used in environments where there is a lot of radiation.</li> <li>● Used in water or in high humidity environments.</li> <li>● Used for the purpose of transporting people or animals.</li> <li>● Use as a foot (e.g., on or depending on the operator)</li> </ul> <ul style="list-style-type: none"> <li>■ Operators who use the operator should wear the safety appliances shown below before carrying out their work.                     <ul style="list-style-type: none"> <li>● Work clothes suitable for the job content</li> <li>● Safety shoes</li> <li>● Safety helmet</li> </ul> </li> </ul> |
|  <p>Prompt</p> | <p>Personnel who carry out programming and maintenance operations must receive appropriate training through the relevant training of the company.</p>   |

Considerations during installation

|  |  |
|--|--|
|  <p>Warning</p> | <ul style="list-style-type: none"> <li>■ When handling and installing the machines, they must be carried out correctly according to the method shown in our manual. If the operation is carried out in the wrong way, it is possible that the operator will be killed or injured due to the overturning of the operator.</li> <li>■ When using the operator for the first time after installation, be sure to do so at a low speed, and then gradually accelerate the speed and confirm that there are any anomalies.</li> </ul> |
|--|--|




Matters needing attention in operation

|  |   |
|--|---|
|  <p>Warning</p> | <ul style="list-style-type: none"> <li>■ When using the operator, be sure to make sure there are no personnel in the safety fence before carrying out the operation. At the same time, check to see if there is a potential danger, and when it is confirmed that there is a potential danger, be sure to eliminate the danger before carrying out the operation.</li> <li>■ When using the instruction device, because there may be errors in the operation of wearing gloves, it is important to take off the gloves before carrying out the work.</li> </ul> |
|--|---|


|   |  |
|---|--|
|  <p>Prompt</p> | <p>Information such as programs and system variables can be stored in storage media such as memory cards. In order to prevent data loss caused by unexpected accidents, it is recommended that users back up data regularly.</p> |
|---|--|

Considerations in programming



|  |   |
|--|---|
| <br>Warning | <ul style="list-style-type: none"> <li>■ When programming, try to do it outside the safety fence,, the following matters shall be taken into account when the safety fence needs to be carried out as a last resort:             <ul style="list-style-type: none"> <li>● Check the safety fence carefully and make sure it is not dangerous before entering the fence.</li> <li>● The emergency stop button can be pressed at any time.</li> <li>● The manipulator shall be operated at low speed</li> <li>● The operation should be carried out after confirming the state of the whole system, so as to avoid the operator falling into a dangerous situation due to the remote control instructions or actions for the peripheral equipment.</li> </ul> </li> </ul> |
| <br>Caution | <p>After the program is finished, it is important to perform the test operation in accordance with the specified procedure. At this time, the operator must operate outside the safety fence.</p>   |
| <br>Prompt  | <p>For operators who are programmed, it is important to receive appropriate training through the company.</p>   |

Attention should be paid to maintenance work

|  |  |
|--|--|
| <br>Warning | <ul style="list-style-type: none"> <li>■ When switching on the power supply, part of the maintenance operation is in danger of electric shock, as far as possible, the maintenance operation should be carried out in the state of power off; professional maintenance personnel should be designated according to the need to carry out maintenance operation; other personnel should be avoided to turn on the power supply when maintaining the operation; even if the power supply must be turned on before the operation can be carried out, the emergency stop button should be pressed and then the operation should be carried out.</li> <li>■ Please consult our company when you need to replace the parts.</li> <li>■ The replacement of parts by the client may result in unexpected accidents, which may cause the operator to be damaged and the operator is injured.</li> <li>■ When entering the security fence, check the whole system carefully and make sure it is not dangerous. If there is a dangerous situation and have to enter the fence, you must grasp the state of the system and be very careful.</li> <li>■ If you need to replace the parts, be sure to use our specified parts. If you use a part other than the specified part, it may cause damage to the operator.</li> <li>■ When removing the motor and brake, the crane hoisting and other measures should be taken to remove the motor and brake, so as to avoid the falling of the manipulator arm.</li> <li>■ When carrying out maintenance operations, when it is necessary to move the operator as a last resort, the following matters should be taken into account:</li> </ul> |
|--|--|

- It is important to ensure that the escape channel is smooth and that the operation should be carried out again under the operation of the whole system in order to avoid blockage of the retreat by the operator and peripherals.
- Always pay attention to the danger around you and be prepared so that you can press the emergency stop button at any time when you need it.
- The auxiliary equipment such as the crane shall be used when the moving motor and the speed reducer and the like have certain weight parts, so as to avoid the excessive work load for the operators. At the same time, it is necessary to avoid the wrong operation, otherwise, the operation and death of the operation may be caused.
- Be careful not to fall because of the lubricating oil that falls on the ground, wipe the lubricating oil that falls on the ground as soon as possible, and eliminate the possible danger.
- Do not place any part of the body on any part of the manipulator during the operation, and it is prohibited to climb on the manipulator, so as to avoid unnecessary personal injury or adverse effect on the manipulator.
- The following parts will be hot and need attention. When you have to touch the equipment when you have to touch it in the event of heat, you should prepare protective appliances such as heat-resistant gloves:
  - Servo motor
  - reducer
  - Adjacent to motor / reducer
  - Inside the control cabinet
- The parts (such as screws, etc.) removed during the replacement of the parts should be correctly loaded back to their original parts, and if the parts are found to be insufficient or surplus, they should be reconfirmed and installed correctly.
- During the maintenance of the pneumatic system and hydraulic system, it is important to release the internal pressure to zero and operate again.
- After replacing the parts, be sure to carry on the test operation according to the prescribed method. At this point, the operator must operate outside the safety fence.
- After the maintenance operation, the grease, debris and water sprinkled on the ground around the operator and inside the safety fence should be thoroughly cleaned.
- When replacing parts, dust and other foreign bodies should be prevented from entering the manipulator.
- Operators who carry out maintenance and repair operations must receive the training of the company and pass the relevant assessment.
- When carrying out maintenance operations, appropriate lighting appliances should be equipped, but care should be taken not to make the lighting appliances a source of new danger.
- Be sure to refer to this specification for regular maintenance, if not regular maintenance, will affect the service life of the operator, and may lead to accidents.

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# 1 Product specification

## 1.1 General functions and intended applications

Industrial robot systems are used to move tools and devices, or process and transport workpieces or products. It is allowed to be used only in accordance with the specified climatic and environmental conditions. For specific storage conditions and working environment requirements, please refer to Chapter 1.2.

All non-compliant use is illegal and prohibited. These non-compliant uses include:

- Use in environments where there is a danger of explosion.
- Use outside the allowed motion range.
- Transporting people or animals.
- Used as a climbing aid.



Changing the structure of the robot, such as drilling holes, can cause component damage. This is regarded as improper use and will result in loss of warranty and claim eligibility.

## 1.2 Environmental conditions and working and storage limitations

### 1.2.1 Environmental requirements

See Table 1-1 for the operating environment requirements of AIR4-560A manipulator.

Table 1-1 Environmental requirements for AIR7-920B equipment manipulator

| Parameter                          | Illustrate   |      |
|------------------------------------|--|------|
| Temperature                        | Lowest temperature   | 0°C  |
|                                    | Maximum temperature  | 45°C |
| Humidity                           | The operating environment requirements of the manipulator do not exceed the humidity level not higher than 95% as specified in the document "IEC 60721-3-3-2002 Classification of environmental conditions". |      |
| Altitude                           | The altitude of the normal operating environment of the manipulator should not exceed 1000 meters. In the height range of 1000 meters-4000 meters, the manipulator should be reduced in rated power to use   |      |
| Shock resistance                   | The robot manipulator should be used in an environment without vibration as much as possible. The limit frequency of environmental vibration is 5Hz ~55Hz, and the amplitude does not exceed 0.15mm.         |      |
| Special environmental requirements | The manipulator is prohibited to use in flammable, explosive and corrosive environment.  |      |



When the ambient temperature is lower than 10°C, it is recommended to warm up the machine for a few minutes before use to avoid changes in grease viscosity causing robot alarms or performance degradation.

## 1.2.2 Environmental conditions for long-term storage

The specific environmental requirements are shown in Table 1-2 below.

Table 1-2 Manipulator long-term storage environmental conditions

| Parameter  | Value  |
|--|--|
| Minimum ambient temperature                              | -25°C  |
| Maximum ambient temperature                              | 55°C   |
| Maximum ambient temperature (storage time less than 24h) | 70°C   |
| Maximum ambient humidity                                 | Less than 95% at constant temperature, no condensation |

## 1.2.3 Precautions for storage

In addition to the content of Chapter 1.2.1 of this manual, the long-term storage of the manipulator should also pay attention to the following items:

- Before long-term storage of the manipulator, the posture should be in the transport posture, placed on a horizontal surface and fixed, see Chapter 3.2.4 of this manual for details.
- When the manipulator is not used for a long time, all power supply should be cut off.
- Use an outer protective cover such as paper or wooden packaging box to protect the manipulator from external light to avoid long-term exposure to the manipulator or exposure to water, oil, corrosive liquids, etc.
- The surface of the manipulator should be cleaned regularly, such as dust removal and decontamination. The specific cleaning cycle depends on the storage environment of the manipulator.
- When the storage period ends and the manipulator is put back into use, the manipulator must be inspected in accordance with Chapter 3.3.1 of this manual.

## 1.3 Basic specifications

The basic specifications of AIR4-560A robot are shown in Table 1-3.

Table 1-3 Basic specifications of AIR4-560A robot

| Parameter                        | Illustrate   |              |
|----------------------------------|--|--------------|
| Coordinate form                  | Six-degree-of-freedom articulated robot                          |              |
| Number of control axes           | 6 axis(J1,J2,J3,J4,J5,J6)  |              |
| Installation method              | Ground installation, wall installation, upside-down installation |              |
| Action range (upper/lower limit) | J1*  | -170° ~+170° |
|                                  | J2   | -110° ~+120° |
|                                  | J3   | -108° ~+152° |
|                                  | J4   | -200° ~+200° |
|                                  | J5   | -118° ~+118° |
|                                  | J6   | -350° ~+350° |
| Maximum operating speed          | J1 450° /s   |              |

| Parameter               |       | Illustrate   |
|-------------------------|-------|--|
|                         | J2    | 450° /s  |
|                         | J3    | 525° /s  |
|                         | J4    | 600° /s  |
|                         | J5    | 600° /s  |
|                         | J6    | 800° /s  |
| Handling weight         | Wrist | 4kg  |
|                         | Elbow | 1kg  |
| Drive method            |       | Use AC servo motor for electrical servo drive  |
| Repeatability           |       | ± 0.02mm   |
| Robot quality           |       | 23kg   |
| Noise                   |       | 70dB (A)   |
| IP protection level     |       | IP65   |
| Installation conditions |       | <ul style="list-style-type: none"> <li>■ Ambient temperature: 0~45℃</li> <li>■ Humidity: within 95% at constant temperature, no condensation</li> <li>■ Allowable height: below 1000m above sea level</li> <li>■ There should be no corrosive, flammable, explosive gases</li> </ul> |



Prompt

"\*\*" stipulates that if the mechanical limit of the J1 axis is removed, the movement range of the J1 axis can reach -180° ~ 180° .

## 1.4 Product naming rules

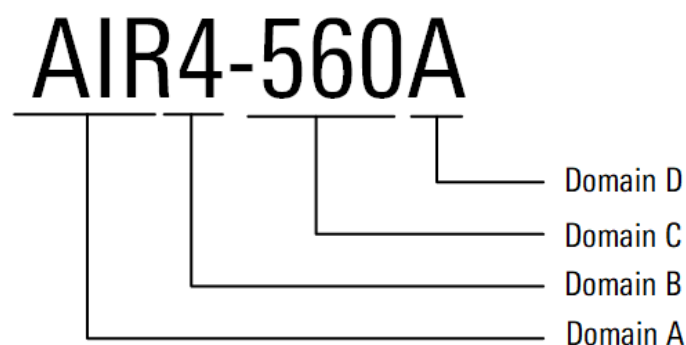


Figure 1-1 Product naming rules diagram

Table 1-4 Product naming rules description

| Domain   | Meaning        | Domain value | Explanation  |
|----------|----------------|--------------|--|
| Domain A | Product series | AIR          | Indicates that this product belongs to the Peitian AIR |

| Domain   | Meaning    | Domain value | Explanation  |
|----------|------------|--------------|--|
|          |            |              | product series.  |
| Domain B | Wrist Load | 4            | Indicates that the robot wrist load does not exceed 4kg. |
| Domain C | Wingspan   | 560          | Indicates that the robot arm has a reach of 560mm.       |
| Domain D | Generation | A            | Indicates the first generation                           |



## 2 Introduction to robot system

---

### 2.1 Introduction to industrial robots

The industrial robot system is mainly composed of three basic parts: industrial robot manipulator, control cabinet and teach pendant:

- Manipulator refers to the mechanism used to grab or move objects (tools or workpieces) in the robot system, also known as the robot body. This manipulator is a six-degree-of-freedom tandem industrial robot, including three swing axes and three rotation axes.
- Control cabinet is installed with the electrical equipment needed to control the robot, and provides a connection interface with the robot manipulator and other external equipment.
- Teach pendant is connected to the main control system of the control cabinet, and is used to control the manual/automatic operation of the robot, record the running track, display playback or record the teaching point and program according to the teaching point.

The structure of AIR4-560A industrial robot system is shown in Figure 2-1.

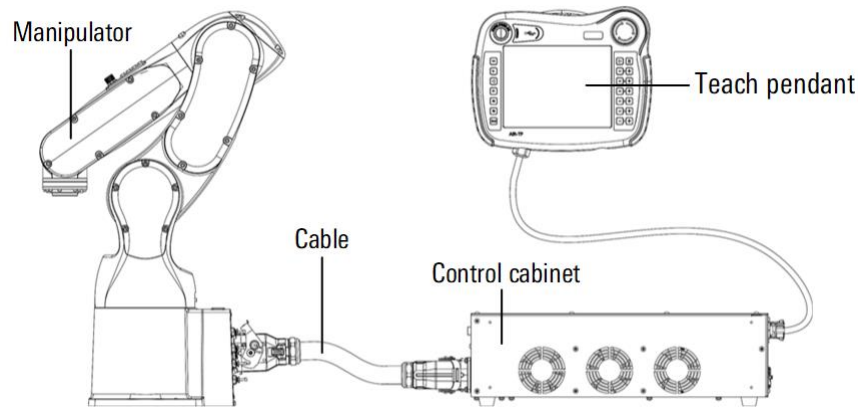


Figure 2-1 The composition of AIR4-560A industrial robot system

### 2.2 Basic configuration of manipulator

The names of AIR4-560A type manipulator and each part of it are shown in Figure 2-2.

For the basic specifications of the AIR4-560A manipulator, please refer to Chapter 1.3 of this manual. For the dimensions and working range of each axis, please refer to Chapter 6.2.1 of this manual.

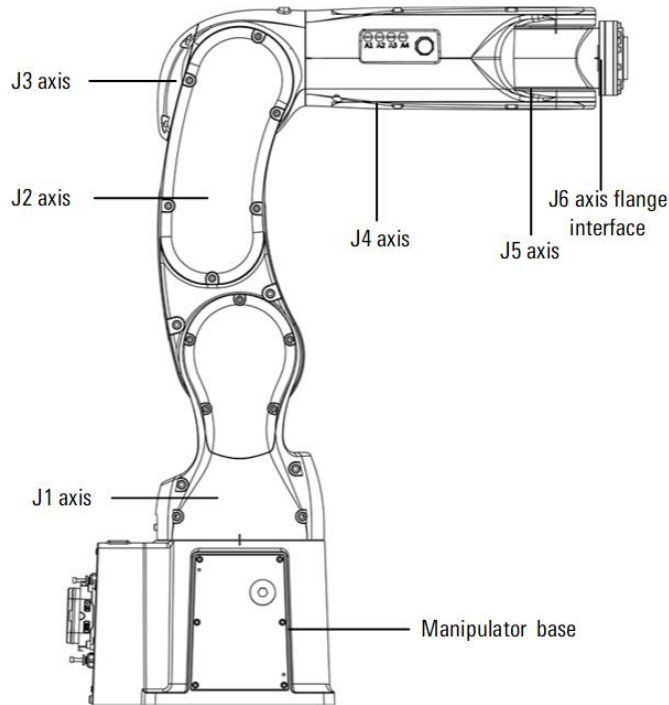


Figure 2-2 AIR4-560A manipulator body and its parts

## 2.3 Product label and meaning

### Manipulator nameplate

The nameplate of the manipulator is attached to the base. The nameplate contains the corresponding model, product number, weight, serial number, production date and other information of the corresponding product (refer to Figure 2-3).

|  |             |
|--|-------------|
|  配天机器人技术有限公司<br>Peitian Robotics Technology Co., Ltd. |             |
| 型号   | Type        |
| 产品号  | Product No. |
| 序列号  | Serial No.  |
| 生产日期   | Date        |
| 重量   | Weight      |
| 负载   | Load        |
| 运动半径   | Range       |

Figure 2-3 Diagram of nameplate of AIR4-560A manipulator

### No approaching label

On the back of the manipulator's upper arm, there is a "No Approaching Label" (as shown in Figure 2-4). Refer to Figure 2-6 for the specific location of the label.



Figure 2-4 No approaching label

|            |   |
|------------|---|
| <br>Danger | Failure to comply with this regulation is extremely easy or may cause unnecessary personal injury or even casualties! |
|------------|---|

Transportation posture label

The transportation posture label of each axis of the AIR4-560A is affixed to the base of the manipulator (as shown in Figure 2-5). Please refer to Figure 2-6 for the label location.

| 搬运姿态<br>Transportation Posture |      |      |    |     |    |
|--------------------------------|------|------|----|-----|----|
| J1                             | J2   | J3   | J4 | J5  | J6 |
| 0°                             | -25° | 152° | 0° | 53° | 0° |

在拆卸基座固定螺钉前，  
机器人必须处于搬运姿态。

The robot must be in the  
“Transportation Posture”  
before the screw bolts of  
the base are loosed.

Figure 2-5 AIR4-560A manipulator transportation posture label

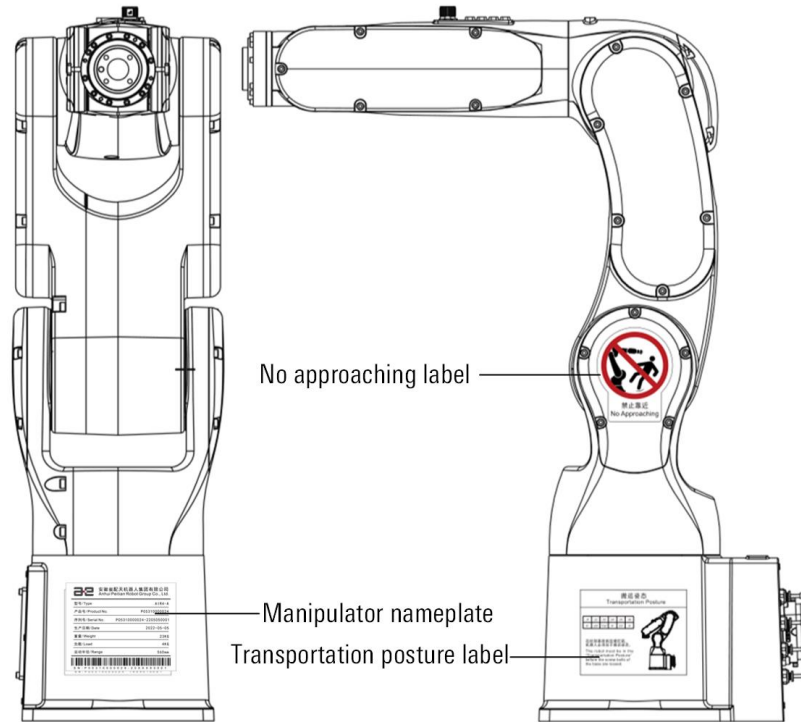


Figure 2-6 Direction identification of each axis on the manipulator

## 3 Preparation before use

---

### 3.1 Safety protection measures before use

Before operating the manipulator and peripheral equipment and the manipulator system composed of them, the safety precautions of the operators and the system must be fully studied. Figure 3-1 is a diagram of the safe work of industrial robots.

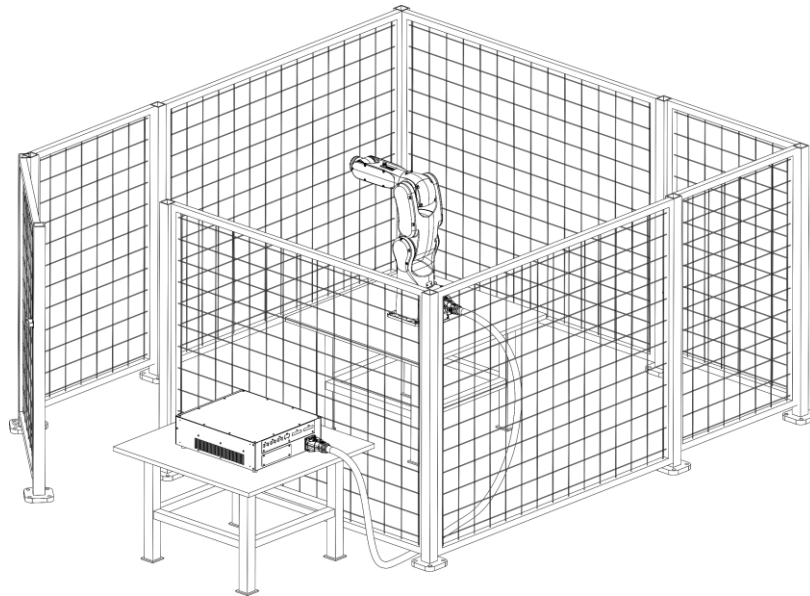


Figure 3-1 Diagram of safe work of industrial robots

#### Definition of operating personnel

Manipulator operation personnel consist of operator, teacher and maintenance engineer who shall satisfy the following conditions:

##### Operator

- Switch on/off the power supply of manipulator.
- Start the manipulator program via the operating panel.
- have no right to operate within the safety barrier

##### Teacher

- Execute the functions of operator.

##### Maintenance Engineer

- Execute the functions of teacher.
- Perform the maintenance (repair, adjustment, replacement, etc.) of manipulator.

#### Safety of operation personnel

Operator, teacher and maintenance engineer shall carefully perform the operation, programming and maintenance of manipulator, and shall at least wear the following items:

- Work clothes suitable for task

- Safety shoe
- Helmet

When the auto system is used, be sure to protect the operation personnel. The measures shall be taken to prevent the operation personnel from entering the range of manipulator.

The general precautions are listed below. Please take the appropriate measures to ensure the safety of operation personnel:

- The operation personnel running the manipulator system shall receive the training from the company and pass the relevant assessment.
- While the equipment is running, even if the manipulator seems to have stopped, the manipulator is possibly waiting for the start signal and is about to act. The manipulator shall be regarded as operating at this state. To ensure the safety of operation personnel, it is necessary to confirm that the manipulator is in the operating state via the audible and visual alarms such as the warning lamp
- Be sure to set the safety barrier and safety door around the system so that the operation personnel cannot enter the safety barrier without opening the safety door. The interlock switch, safety pin, etc. shall be set on the safety door so that when the operator opens the safety door, the manipulator will stop.
- Peripheral equipment shall be electrically grounded.
- The peripheral equipment shall be set outside the range of manipulator if possible.
- The range of manipulator shall be clearly marked with the lines on the floor to make the operator understand the range of manipulator including the mechanical arm and other tools.
- A proximity switch or photoelectric switch shall be installed on the floor so that when the operation personnel are about to enter the range of manipulator, the audible and visual alarms such as the buzzer are issued to stop the manipulator, thereby ensuring the safety of operation personnel.
- A lock shall be set to make sure that the manipulator power cannot be turned on except by the operation personnel responsible for the operation.
- Always disconnect the manipulator power when performing the individual commissioning of peripheral equipment.

## Safety of operators

Emergency stop button shall be set within the reach of operators.



Prompt

Manipulator controller is designed to be connected to an external emergency stop button. With this connection, the manipulator will stop when the external emergency stop button is pressed.

## Safety of teachers

In some cases, it is necessary to enter the scope of operation of the operator when carrying out the operation of the operator, especially at this time, the safety should be paid attention to:

- If you do not need to enter the operation maneuvering range, be sure to operate outside the operating maneuvering range.
- Before proceeding with the teaching, verify that the manipulator or peripheral equipment is in a safe state.
- If it is inevitable to enter the range of manipulator to conduct the teaching, first confirm the positions and states of safety devices (such as the emergency stop button, emergency automatic stop switching of teach pendant, etc.).
- Teachers shall pay special attention to make other people away from the range of manipulator
- Before starting the manipulator, first confirm that there is no people and no abnormality in the range of manipulator.

- After the teaching is over, be sure to perform the test run following the steps below:
  - Step1.At low speed, execute at least one cycle intermittently to confirm no abnormality.
  - Step2.At low speed, execute at least one cycle continuously to confirm no abnormality
  - Step3.At intermediate speed, execute at least one cycle continuously to confirm no abnormality
  - Step4.At operating speed, execute at least one cycle continuously to confirm no abnormality
  - Step5.Execute the program in automatic operation mode.

## 3.2 Product unpacking

### 3.2.1 Unpacking method

As shown in Figure 3-2, the packaging box of the AIR4-560A manipulator is composed of a box body and a bottom support.

Operation process of unpacking:

- Step1.Use a wrench to unscrew the screws, washers and nuts connecting the cabinet and the base to separate the cabinet and the base.
- Step2.Open the packaging bag of the wrapping machine and take out the built-in calcium chloride desiccant.
- Step3.Use an allen wrench to unscrew the 5 M10 and 4 M5 hexagonal cylindrical head screws, washers and nuts that connect the manipulator, the end support and the bottom bracket, and you can separate the manipulator from the bottom bracket and the end support. Due to loose screws during disassembly, please be careful not to tilt the manipulator and prevent it from tipping over.

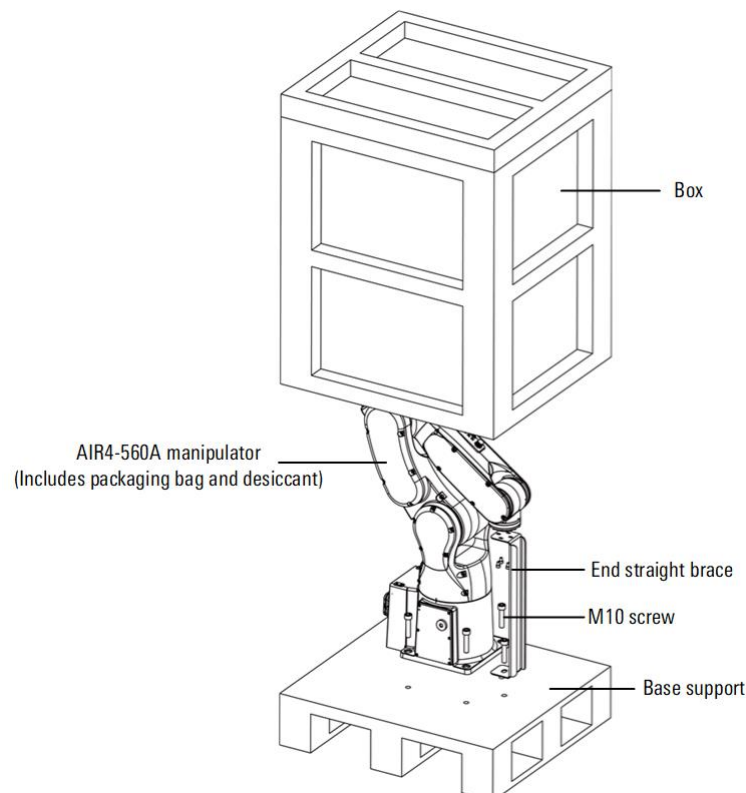


Figure 3-2 Composition of the AIR4-560A manipulator packaging box

### 3.2.2 Repackaging to prevent transportation damage

The operation process for unpacking:

Step1.To facilitate further transportation, repackaging should use the first packaging box, bottom bracket, end support components, and fasteners. To avoid moisture during transportation, please configure the packaging bag and calcium oxide desiccant yourself.

Step2.According to the position shown in Figure 3-2, transport the AIR4-560A manipulator to the center position of the base bracket. Use an Allen wrench to tighten the M10 screws, washers, and M10 nuts connecting the AIR4-560A manipulator, base bracket, and end support to secure the manipulator to the base bracket.

Step3.According to the position shown in Figure 3-2, place the box on the bottom support, and use a wrench to tighten the screws, washers, and nuts that secure the box and bottom support.

### 3.2.3 Safe disposal of packaging materials

- In order to facilitate repacking, please properly save the carton, the bottom bracket and all the screws and nuts and other parts used in connection. Please keep the above materials in a dry and clean indoor place to prevent the materials from moisture, pressure, heat or close to fire source.
- If you don't need to keep the above materials, please handle them properly according to the relevant disposal methods of industrial waste.
- The packaging bag and calcium chloride desiccant cannot be used again after unpacking, please handle it properly according to the relevant disposal methods of industrial waste.

### 3.2.4 Disposal of waste materials

Industrial robot system waste disposal must be carried out in accordance with the laws, regulations and standards of each country.

## 3.3 Preparation before installation

### 3.3.1 Installation precautions

Following requirements shall be strictly adhered to before installation:

- Ensure that the installers pass the relevant training of company and perform the installation according to the international and local laws and regulations.
- After the unpacking, make sure that the product is not bumped or damaged
- Make sure that the carrier bracket, swinging ring screws, etc. are installed to the manipulator as required.
- Make sure the installation environments are as required by Chapter 1.2.
- Make sure that the installation site can withstand the pressure or pull from the manipulator and its load.

### 3.3.2 Installation tools and required connectors

The following tools may be required to install the manipulator (more tools may be required, depending on the specific installation method):

- An allen wrench
- Adjustable wrench
- Torque wrenches of different specifications, etc.



The connection parts that may be required for the installation of the manipulator are as follows (more connection parts may be required, depending on the specific installation):

- Several M10 cylindrical head hexagon socket screws with appropriate length and strength grade of 12.9 or other size specifications.
- Several chemical bolts with appropriate length and strength grade not less than 4.8.
- Several spring pads of  $\Phi 10$  or other specifications.
- There are several cylindrical pins with a diameter of 6mm. For details, see Chapter 3.4.2 of this manual.

## 3.4 Installation and assembly

### 3.4.1 Technical specifications



Prompt

When installing the manipulator, the strength of the foundation installation surface should be fully considered. The inclination of the manipulator installation ground should be less than  $5^\circ$ .

The dimensions of the AIR4-560A manipulator base are shown in Figure 3-3.

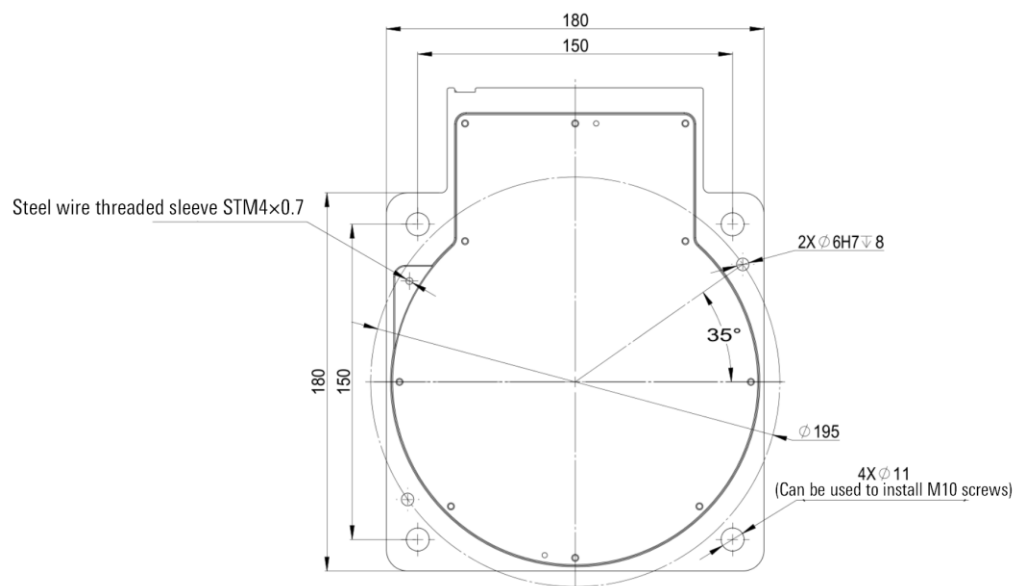


Figure 3-3 AIR4-560A manipulator base interface size

### 3.4.2 Fixed way

The manipulator provides two fixing methods: "ground fixing" and "bracket fixing".



Prompt

- The specific fixing method should be appropriately selected according to the environment used by the user.
- The strength of chemical bolts is affected by the strength of concrete. For the construction of chemical bolts, please refer to the design guidelines of each manufacturer and fully consider the safety before use.

Table 3-1 shows the names and specifications of the parts and components required to fix the manipulator.

Table 3-1 Parts required for AIR4-560A manipulator fixing

| Parts name        | Remarks                                  | Ground fixed | Bracket fixed |
|-------------------|--|--------------|---------------|
| Fixing screws     | 4 M10x50 (grade 12.9)                    | ○            | ○             |
| Chemical bolt     | 4 M20 (strength grade not less than 4.8) | ○            |               |
| Robot fixed plate | 20mm thickness, 1 piece                  | ○            |               |
| Mounting brackets | Mounting plate thickness 20mm            |              | ○             |



Prompt

- There shall be no insulation material between the robot fixing plate and the mounting bracket and the manipulator.
- The representatives with "○" mark need this part.
- The bracket shall be stably installed on the ground, and the strength shall not be less than that of the robot fixing plate and the ground in the ground fixation.

## Ground fixed

Fixing steps:

Step1. According to the recommended size shown in Figure 3-4, arrange M20 chemical bolts (strength grade not less than 4.8) on the concrete foundation. Please strictly follow the instructions for the selected chemical bolts for installation;

Step2. Place the robot fixing plate close to the installation plane. After placing it securely, fix it with four M20 hexagon nuts (strength grade not less than 4.8) and M20 flat washers;

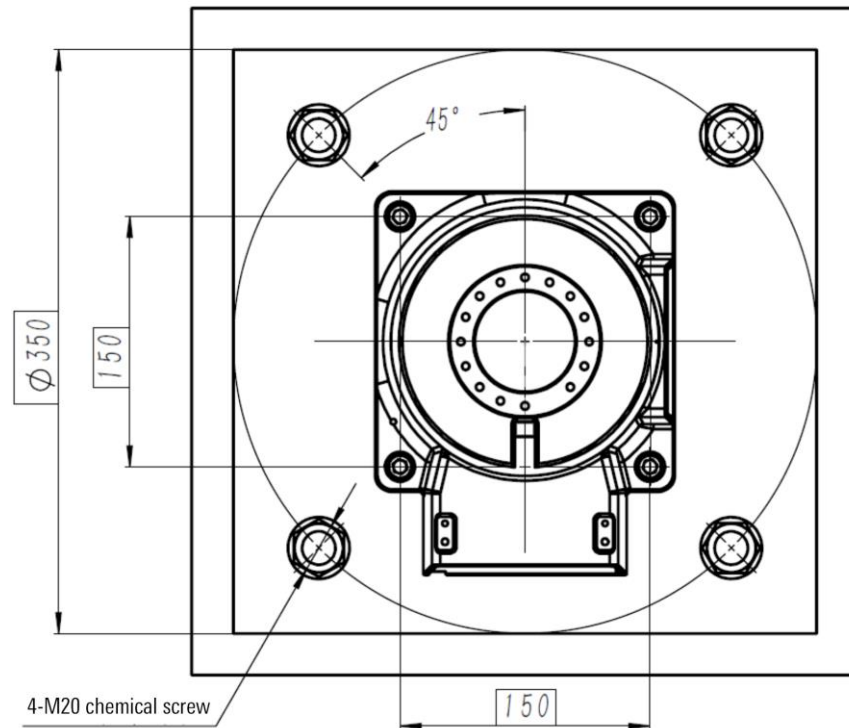
Step3. In the handling attitude (refer to Chapter 7), transfer the manipulator to the upper part of the robot fixing plate and adjust the direction of the manipulator so that the through hole position of the base  $\phi 11$  is aligned with the threaded hole position of the robot fixing plate M10;

Step4. Check that the base is tightly attached to the retainer plate without shaking and mount the manipulator base fixedly to the retainer plate using four M10 x 30 bolts (strength class 12.9).

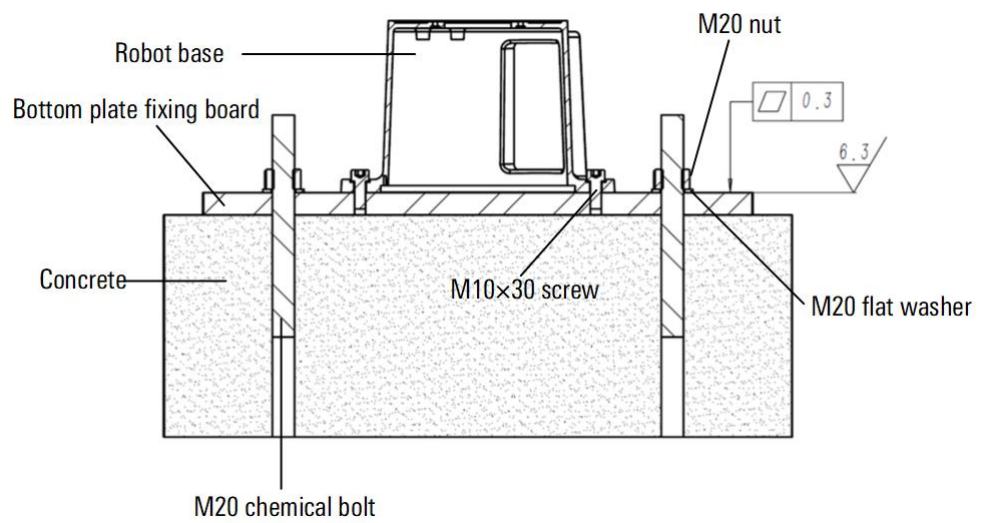


Prompt

The mounting surface of the bracket shall meet certain planarity requirements, and the planarity of the mounting surface shall be within 0.3.



(a) Layout size



(b) Section view

Figure 3-4 Ground fixed diagram


Bracket fixed

|             |  |
|-------------|--|
| <br>Warning | <ul style="list-style-type: none"> <li>■ The length of the manipulator fixing screw M10 should not be shorter than 30mm. Too short length will cause accidents such as poor fixing.</li> <li>■ When installing the manipulator on the ceiling, it is necessary to increase the length of the manipulator fixing screw to 35mm, while ensuring that the thickness of the mounting plate is not less than 25mm.</li> </ul> |
|-------------|--|

Fixing steps:

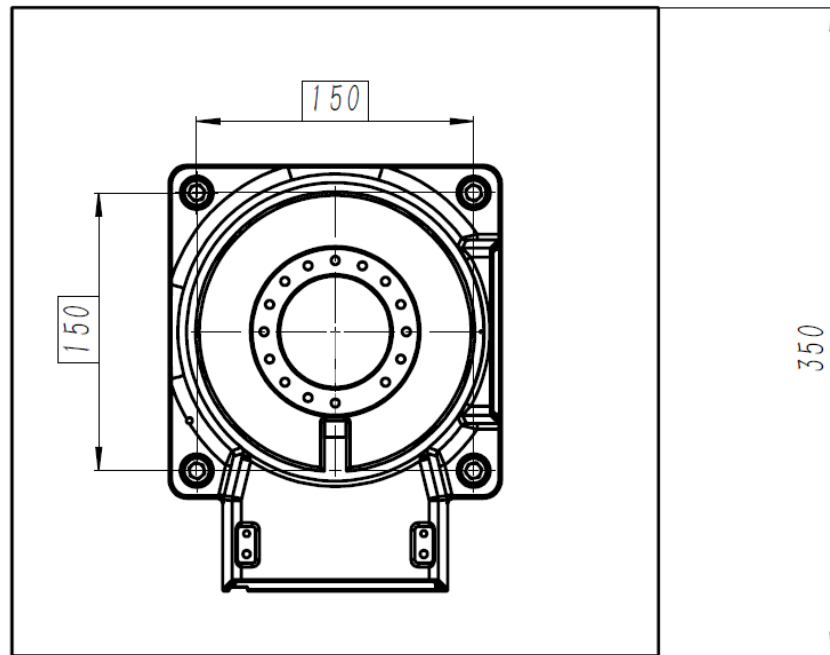
Step1. In handling posture, transfer the manipulator to the mounting bracket and adjust the direction of the manipulator to align the hole position of the through hole of the base  $\phi 11$  with the hole position of the threaded hole of the mounting bracket M10.

Step2. Check that the base fits snugly on the surface of the mounting bracket without shaking and fix the manipulator base to the bracket using four M10 x 30 bolts (strength class 12.9).

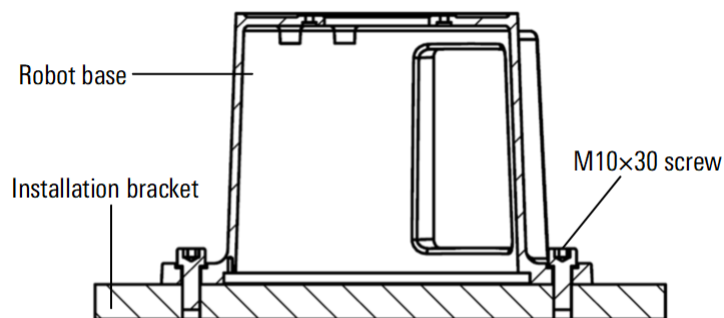


Prompt

The mounting surface of the bracket shall meet certain planarity requirements, and the planarity of the mounting surface shall be within 0.3.



(a) Plane layout dimensions



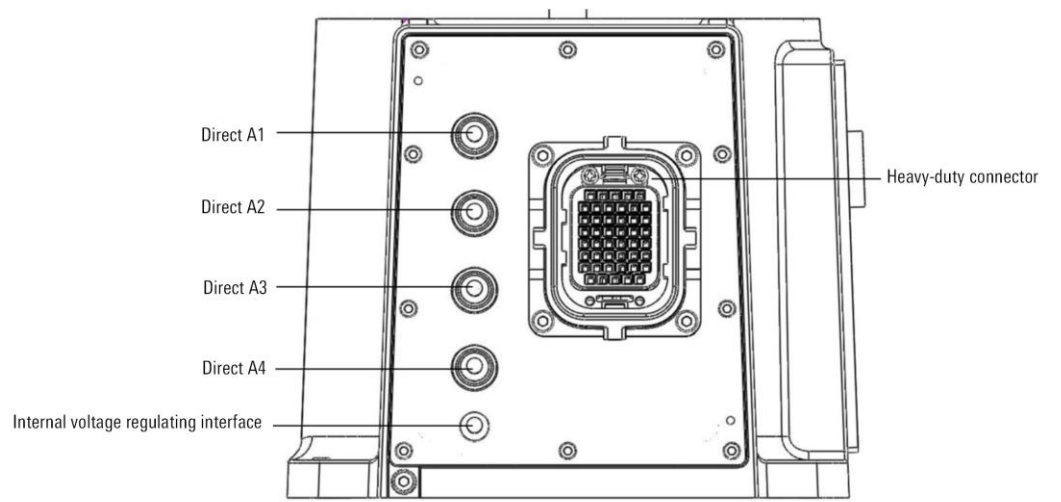
(b) Sectional view

Figure 3-5 Diagram of manipulator bracket fixation

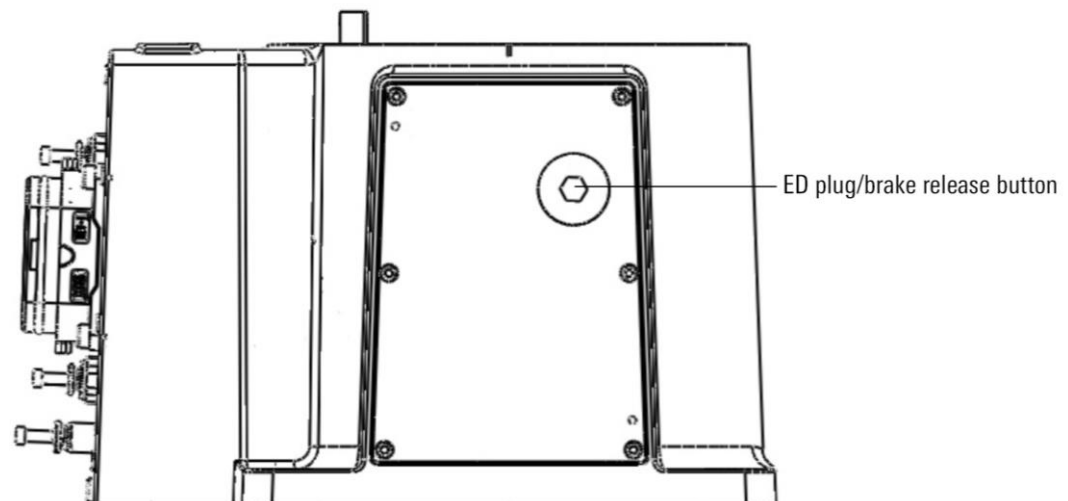
## 4 Electrical interface

### 4.1 Manipulator electrical interface type

There are heavy-duty connectors, air pipe interfaces and manual brake release buttons on the base of the AIR4-560A. As shown in Figure 4-1(a), the right side is a heavy-duty connector, and the left side is four  $\phi 4$  quick air pipe joints and an internal pressure regulating interface. After pulling out the blind plug, the  $\phi 4$  air pipe can be directly inserted; Figure 4-1 (b) As shown, inside the ED plug is a manual brake release button.



(a)



(b)

Figure 4-1 Diagram of the electrical interface on the AIR4-560A manipulator base

The forearm of the AIR4-560A manipulator has an aviation socket (forearm IO interface) and an air path that is directly connected to the base air pipe joint. The specific location is shown in Figure 4-2. The straight air path is blocked by an M5 screw plug. If needed, unscrew the screw plug and connect the appropriate M5 air pipe connector.

The operation process of manually releasing the brake is as follows:

Step1.To prevent the axis from falling due to gravity when the brake is released, the manipulator needs to be fixed;

Step2.Use a wrench to remove the ED plug on the base, and you can see the release button inside the base;

Step3.Connect the manipulator to the control cabinet, and connect the control cabinet to the power supply. For details, see *Chapter 5*;

Step4.Press and hold the brake release button, the brakes of the 6 axes of the manipulator can be released.

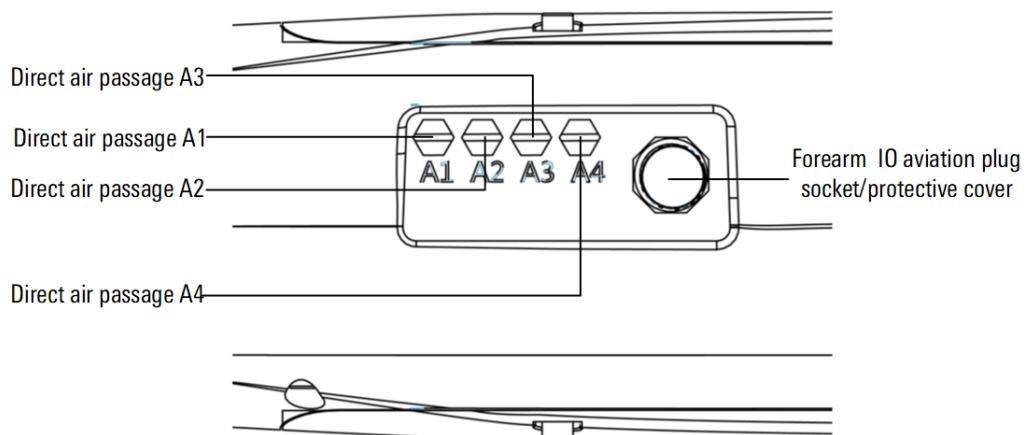
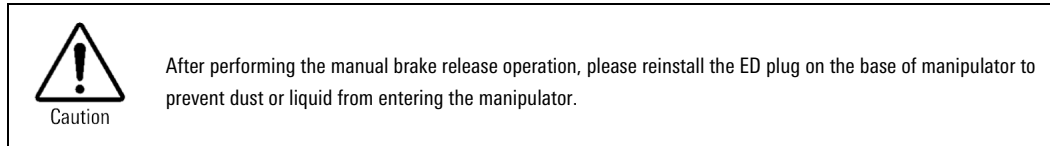
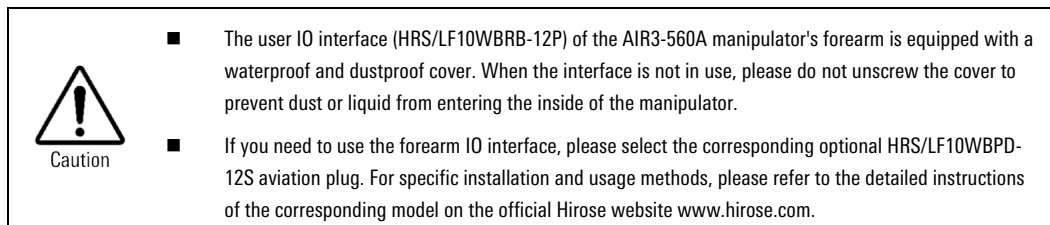


Figure 4-2 AIR4-560A manipulator forearm upper interface



## 4.2 Manipulator side heavy-duty interface

The heavy-duty interface of the AIR4-560A manipulator is shown in Figure 4-3.

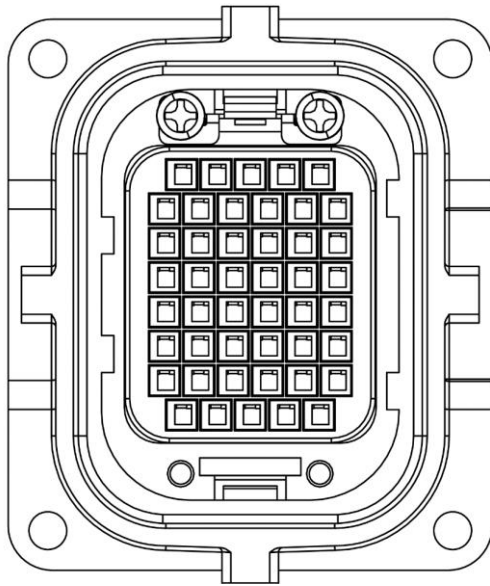



Figure 4-3 Diagram of heavy-duty interface of AIR4-560A type manipulator

|   |  |
|---|--|
| <br>Prompt | When the robot is connected to the control cabinet, either end of the heavy-duty cable can be plugged into the manipulator or the control cabinet. |
|---|--|

### Manipulator side heavy-duty joint dimensions

The diagram of the side heavy-duty plug dimensions of the manipulator is shown in Figure 4-4.

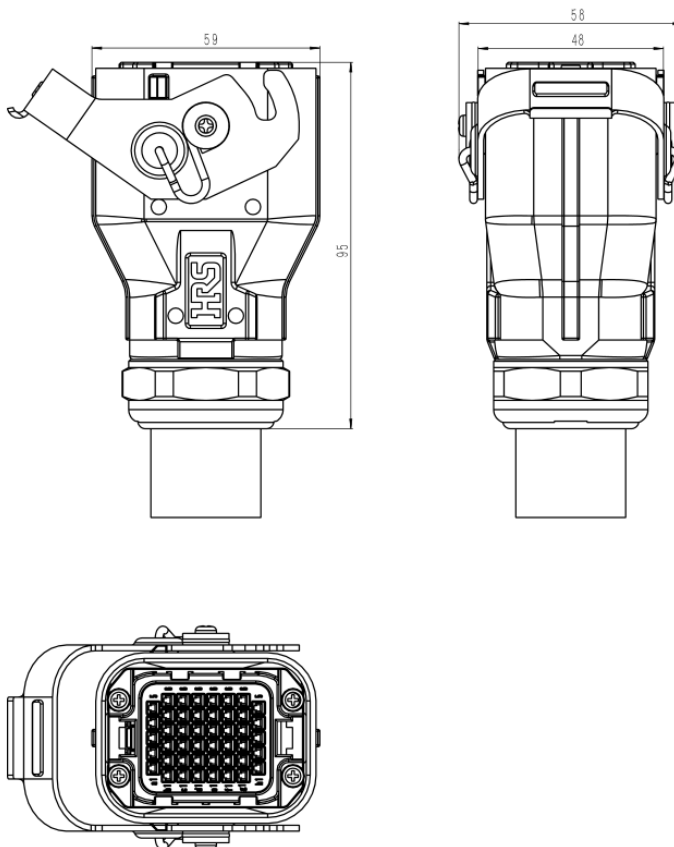


Figure 4-4 Manipulator side heavy-duty size

## Power line part interface definition

The heavy-duty interface definition (power line part) of the AIR4-560A manipulator is shown in Table 4-1.

Table 4-1 Definition of heavy-duty interface of manipulator (power line part)

| Signal Name | Axis No. | Pin No. | Signal Name | Axis No. | Pin No. |
|-------------|----------|---------|-------------|----------|---------|
| U1          | Axis 1   | 1f      | U4          | Axis 4   | 5f      |
| V1          | Axis 1   | 1g      | V4          | Axis 4   | 5g      |
| W1          | Axis 1   | 1h      | W4          | Axis 4   | 5h      |
| PE          | Axis 1   | 1d      | PE          | Axis 4   | 4d      |
| U2          | Axis 2   | 4f      | U5          | Axis 5   | 3f      |
| V2          | Axis 2   | 4g      | V5          | Axis 5   | 3g      |
| W2          | Axis 2   | 4h      | W5          | Axis 5   | 3h      |
| PE          | Axis 2   | 4d      | PE          | Axis 5   | 1d      |
| U3          | Axis 3   | 2f      | U6          | Axis 6   | 5e      |
| V3          | Axis 3   | 2g      | V6          | Axis 6   | 6f      |
| W3          | Axis 3   | 2h      | W6          | Axis 6   | 6g      |
| PE          | Axis 3   | 1d      | PE          | Axis 6   | 4d      |

## Encoder line part interface definition

The heavy-duty interface definition (encoder line part) of the AIR4-560A manipulator is shown in Table 4-2.

Table 4-2 Manipulator heavy-duty interface definition (encoder line part)

| Signal Name | Axis No. | Pin No. | Signal Name | Axis No. | Pin No. |
|-------------|----------|---------|-------------|----------|---------|
| J1_PS+      | Axis 1   | 1a      | J4_PS+      | Axis 4   | 4a      |
| J1_PS-      | Axis 1   | 1b      | J4_PS-      | Axis 4   | 4b      |
| J2_PS+      | Axis 2   | 2a      | J5_PS+      | Axis 5   | 5a      |
| J2_PS-      | Axis 2   | 2b      | J5_PS-      | Axis 5   | 5b      |
| J3_PS+      | Axis 3   | 3a      | J6_PS+      | Axis 6   | 6b      |
| J3_PS-      | Axis 3   | 3b      | J6_PS-      | Axis 6   | 6c      |
| Encoder 0V  | Axis 1-6 | 1c      | Encoder 24V | Axis 1-6 | 2c      |

## 4.3 Cabinet side heavy-duty line interface

### Cabinet side heavy-duty connector dimensions

The diagram of the size of the heavy-duty plug on the cabinet side is shown in Figure 4-5.



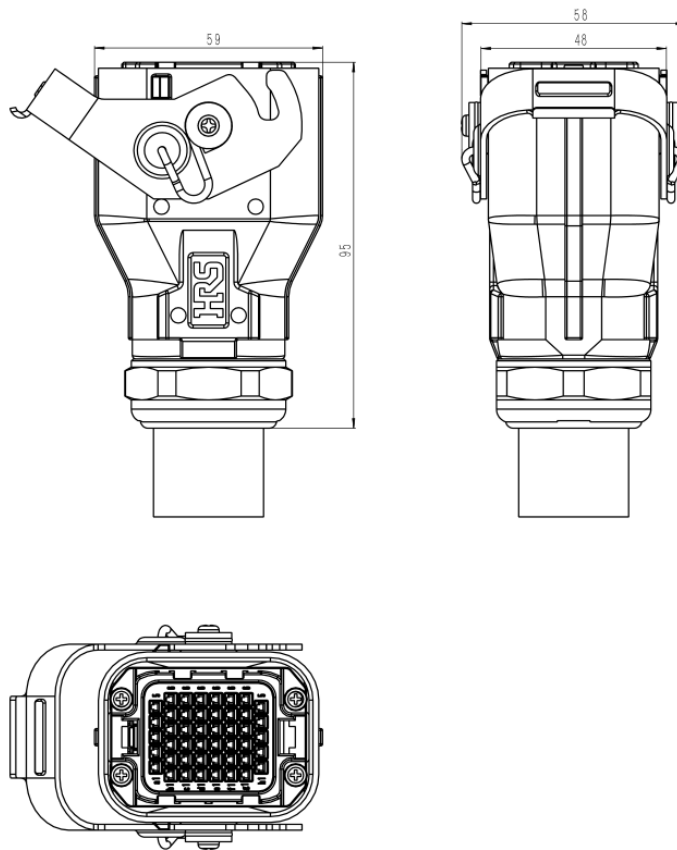


Figure 4-5 Dimensions of heavy-duty connectors on the cabinet side

## 4.4 Manipulator brake and forearm I/O Interface

### Interface definitions for brake and forearm IO section

The definition of the heavy-duty interface of the AIR4-560A manipulator (brake and arm IO parts) is shown in Table 4-3.

Table 4-3 Definition of heavy-duty interface of manipulator (brake and arm IO part)

| Signal name          | Axis number     | Pin number |
|----------------------|-----------------|------------|
| 24V_BR+              | Axis 1 ~ Axis 6 | 3e         |
| 24V_BR+2_0           | Axis 1~ Axis 6  | 2e         |
| GND_24VBR            | Axis 1~ Axis 6  | 1e         |
| E_NAME_BOARD_RS485_A | -               | 4c         |
| E_NAME_BOARD_RS485_B | -               | 3c         |

The definition of the IO interface of the forearm of the AIR4-560A manipulator is shown in Figure 4-6. The relevant descriptions of each interface are detailed in Table 4-4. The forearm IO interface only supports PNP type sensors.

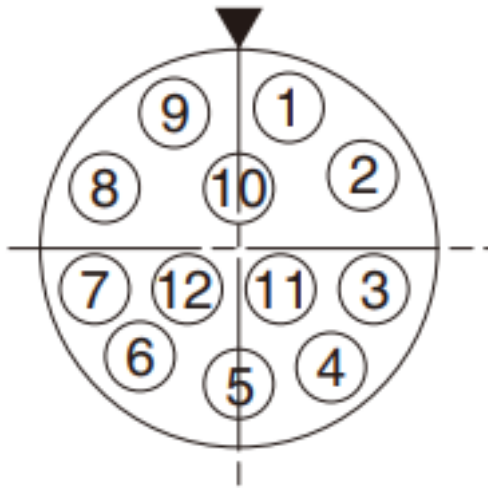


Figure 4-6 Diagram of the IO interface of the forearm of the AIR4-560A manipulator

Table 4-4 Forearm IO interface definition

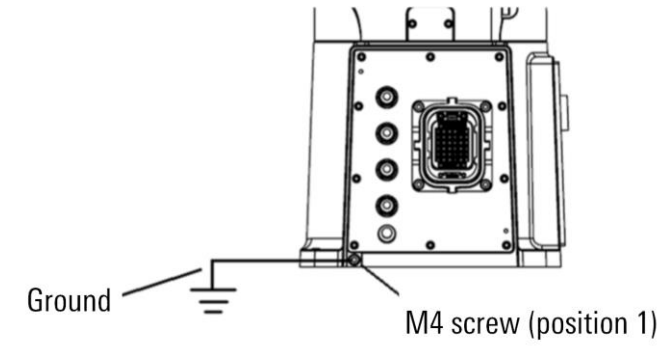
| Signal name | Cable color | Connector number |
|-------------|-------------|------------------|
| 24V         | Black       | 8                |
| GND         | Yellow      | 9                |
| DO0         | White       | 6                |
| DO1         | Brown       | 7                |
| DI0         | Red         | 1                |
| DI1         | Blue        | 2                |
| DI2         | Green       | 3                |
| DI3         | Orange      | 4                |
| DI4         | Grey        | 5                |

## 4.5 Grounding instructions

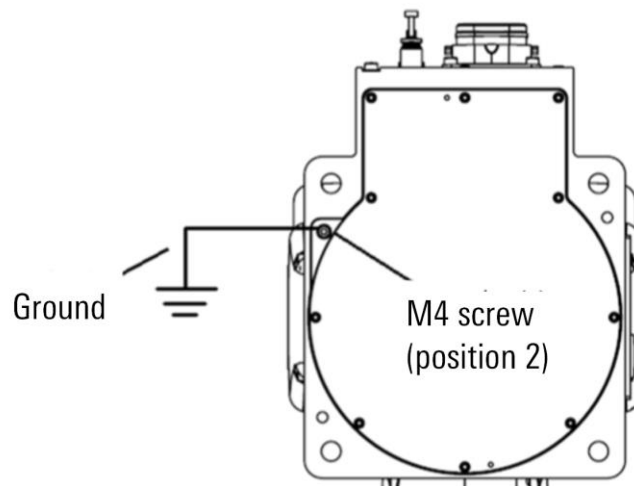
The manipulator requires a reliable grounding, and the purpose of grounding includes but is not limited to the following:

- Avoid the situation where the outer shell of the manipulator becomes charged due to insulation failure of the wires, in order to protect the operators from electric shock.
- Provide a common reference zero potential to the circuit, so that there is no potential difference between the grounds of each circuit, ensuring the stable operation of the system.
- Prevent interference from external electromagnetic fields on sensitive electrical equipment inside.
- Reduce the lightning-induced current that may damage the equipment and avoid damaging internal electronic devices.

The grounding point/connection point is on the base of the manipulator in Figure 4-7. The user needs to ground one end of the wire and fix the other end to the base using a suitable terminal and M4 bolt. The contact surface between the terminal and the base should be cleaned thoroughly to ensure conductivity.



(a)



(b)

Figure 4-7 Grounding method of AIR4-560A manipulator



## 5 Adaptation and connection of products with other devices

### 5.1 Connection between manipulator and control cabinet

As defined in Chapter 4.2 of this manual, the heavy-duty connector on the manipulator is connected to the control cabinet through a cable. The two ends of the heavy-duty line are used to connect the manipulator and control cabinet, and the heavy-duty line does not distinguish between the manipulator and control cabinet ends (see Figure 5-1 and Figure 5-2).

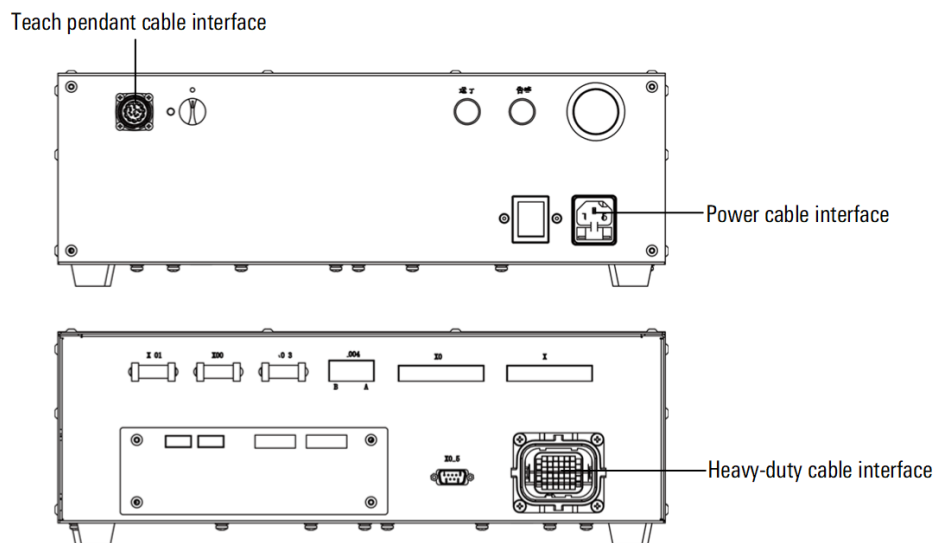


Figure 5-1 AIR4-560A control cabinet cable connector definition

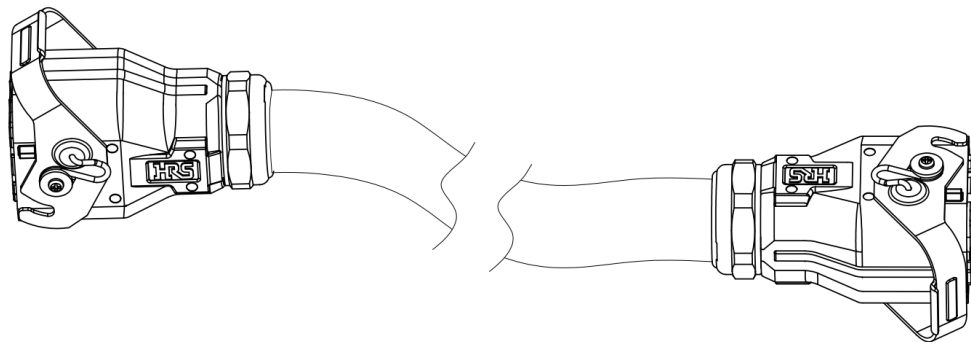


Figure 5-2 Diagram of heavy-duty line

Connection steps:

Step1. Connect the manipulator, insert one end of the heavy-duty wire plug into the manipulator's heavy-duty wire connection port (see Figure 5-3), and tighten the locking buckle.

Step2. Connect the control cabinet, insert one end of the heavy-duty wire plug into the heavy-duty wire connection port of the control cabinet (see Figure 5-4), and tighten the locking buckle.

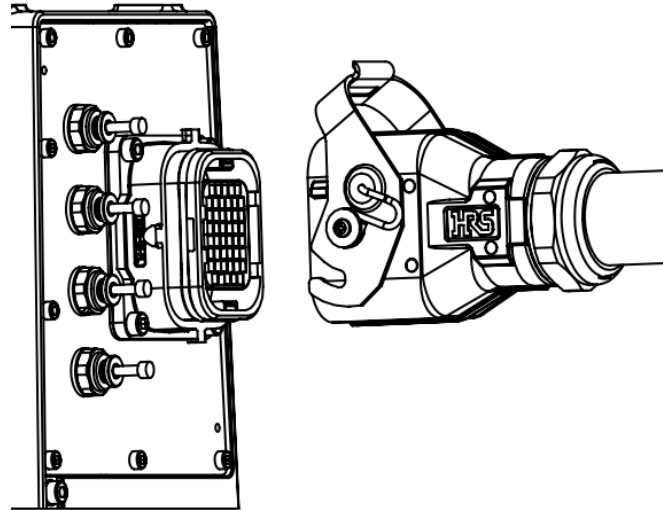


Figure 5-3 Connection interface for the manipulator's heavy-duty line

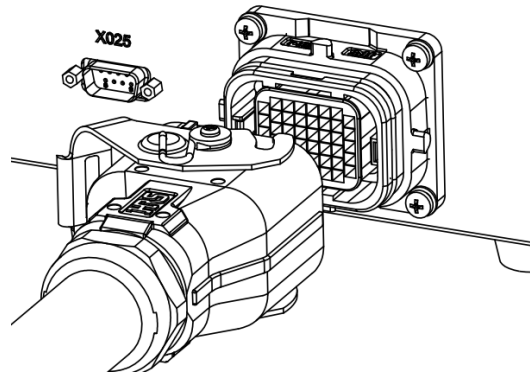


Figure 5-4 Control cabinet heavy-duty connector interface

## 5.2 Connection between the manipulator and the power supply

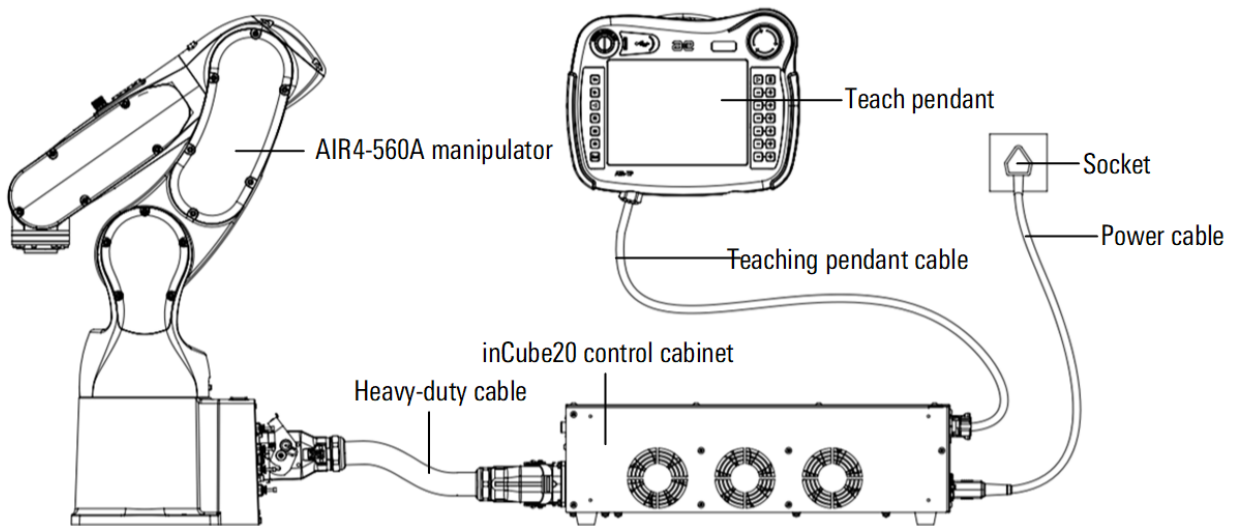


Figure 5-5 Overview of industrial robot system wiring

Both ends of the power cord are used to connect the control cabinet and power supply (see Figure 5-5).

Connection steps:

Step1.Connect the control cabinet and insert the power cord pin shaped plug into the power cord connection port of the control cabinet (see Figure 5-6).

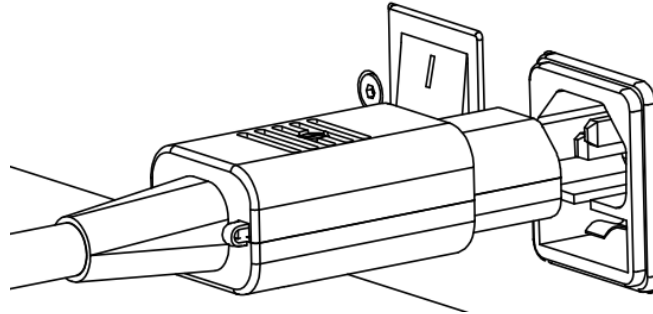


Figure 5-6 Power cord connection interface

Step2.Connect the power supply and insert the three pronged plug of the power cord into the power socket.

Step3.Confirm that the on-site power supply voltage and current meet the requirements of the control cabinet (providing a voltage of 220VAC and meeting a peak current load of at least 10A).

Step4.Confirm that the system short circuit module of the control cabinet is connected normally (X005 in Figure 5-7 is the state of normal connection).

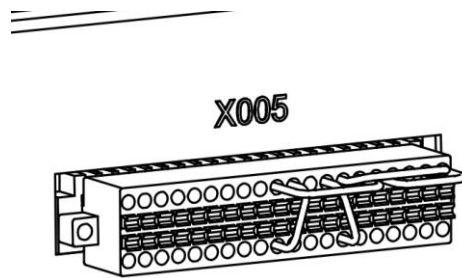


Figure 5-7 System short circuit module

Step5.After power supply, switch the rocker switch from "0" to "I" (refer to Figure 5-8), start the control cabinet, and at the same time, the switch's built-in light will light up, and the teach pendant will start.



Figure 5-8 Control cabinet power switch

Step6.Before powering off, please confirm that the program has stopped running. After the motor is powered off, turn off the switch on the control cabinet to turn it off. It is prohibited to directly unplug the power cord.

### 5.3 Connection between manipulator and accessories

The connection between the external auxiliary equipment of the manipulator and the manipulator, as well as the connection between the heavy-duty and the manipulator, can be directly or indirectly connected to the manipulator through flanges, as detailed in Chapter 6.5 of this manual.

The accessory equipment of the manipulator mainly includes mechanical grab (Figure 5-9), hydraulic pressure sucker (Figure 5-10), welding gun welder (Figure 5-11), infrared identification equipment, visual identification equipment, cutting machine, other special equipment, etc.

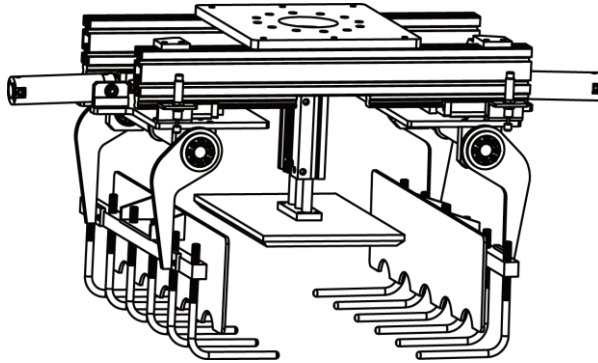


Figure 5-9 Industrial robot grab

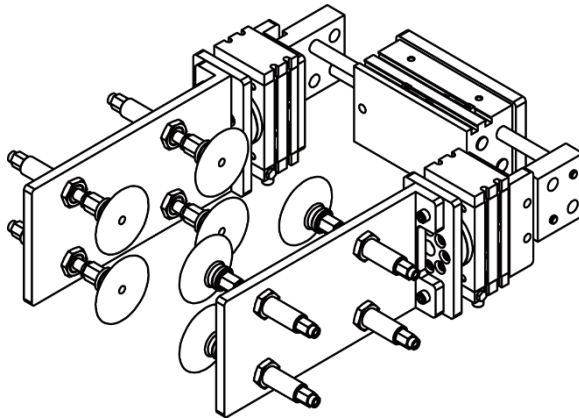


Figure 5-10 Suction cups for industrial robots

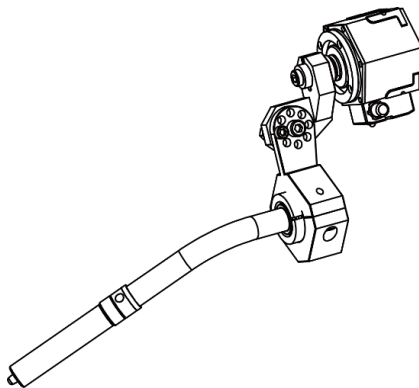


Figure 5-11 Arc welding gun for industrial robot



## 6 Job description

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### 6.1 Safety precautions

#### Safety of peripheral equipment

##### Program related precautions:

- The detection devices such as the limit switch shall be used to detect the dangerous status, and the manipulator shall be stopped as needed according to the signals of detection device.
- In case of abnormalities of other manipulators or peripheral equipment, the measures shall be taken, such as stopping the manipulator, even if there is no abnormality in the manipulator.
- For the system of which the manipulator is operating synchronously with the peripheral equipment, special care shall be taken to avoid the interference with each other.
- The manipulator may be interlocked with peripheral equipment and the manipulator may be stopped if required so as to control the status of all devices in the system from the manipulator.

##### Mechanical precautions:

- Manipulator system shall be kept clean and the use environments shall be free of grease, water, dust, etc.
- Do not use the cutting fluids and cleaning agents of unknown nature.
- Limit switches and mechanical brakes shall be used to limit the operation of manipulator to avoid the collisions between the manipulator and peripheral equipment.
- User cables and hoses shall not be added to the manipulator.
- When installing the cable outside the manipulator, do not interfere with the movement of machine.
- For the models of which the cable is exposed, do not conduct the modification that will interfere with the exposed part of cable.
- When installing the external device on the manipulator, be sure not to interfere with other parts of manipulator.
- For the manipulator in action, the frequent power-off operation via the emergency stop button may lead to the fault of manipulator.

#### Mechanical Safety of Manipulator

##### Precautions for Operation:

When the manipulator is operated in slow feed mode, the operators shall be highly vigilant regardless of the circumstances and quickly respond to various problems.

##### Precautions in terms of procedures:

If the ranges of multiple manipulators overlap, care shall be taken to avoid the interference between manipulators.

Be sure to specify an operation origin for the manipulator program and create a program that starts and ends at the origin, so that it is clear from the outside whether the manipulator operation has ended.

##### Mechanism Precautions:

The working environments of manipulator shall be kept clean and free of grease, water, dust, etc.

### Safety of end effector

When controlling various types of transmissions (pneumatic, hydraulic, and electrical), after issuing the control command, be sure to fully consider the time difference from the issuance to the actual action and conduct the control with certain room of extension and retraction.

A detection unit shall be set on the end effector to monitor the status of end effector and control the action of manipulator.

## 6.2 Safe operation

### 6.2.1 Dimensions and working range of each axis

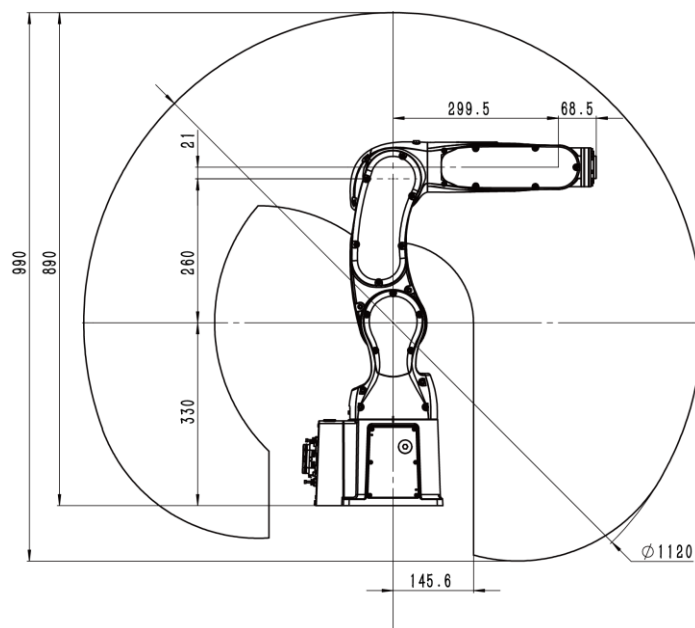
The motion range of each axis of AIR4-560A manipulator is shown in Table 6-1.

Table 6-1 Motion range of each axis of AIR4-560A manipulator

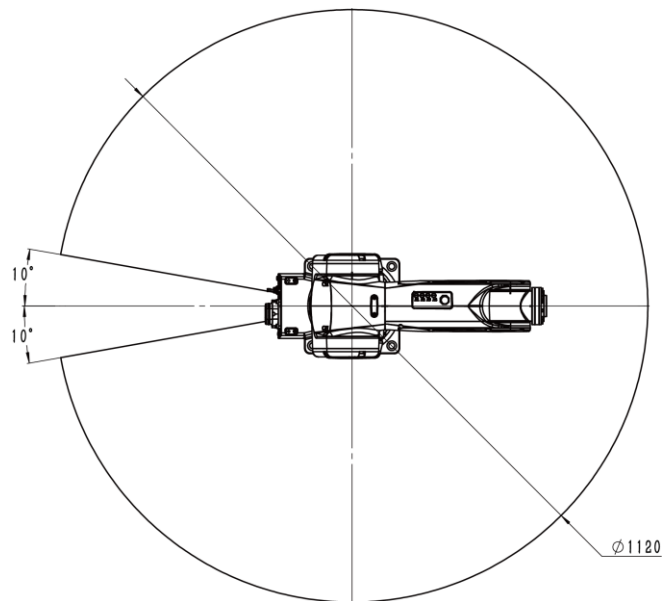
| Axis No. | Motion range(° ) |
|----------|------------------|
| J1       | -170° ~+170°     |
| J2       | -110° ~+120°     |
| J3       | -108° ~+152°     |
| J4       | -200° ~+200°     |
| J5       | -118° ~+118°     |
| J6       | -350° ~+350°     |

The motion range of the manipulator is shown in Figure 6-1.

When installing peripheral equipment, be careful not to interfere with the main body of the robot and its range of motion. Unit: mm.



(a)



(b)

Figure 6-1 Working range of the AIR4-560A manipulator

## 6.2.2 Mechanical limit

On each axis of the manipulator, a zero point and a movable range are respectively provided. As long as the origin position is not lost due to a servo system error or a system error, the robot is controlled to move within the range of motion. In addition, in order to further ensure safety, a mechanical brake is provided on some axes to limit the movable range.

Figure 6-2 shows the position of mechanical brake.

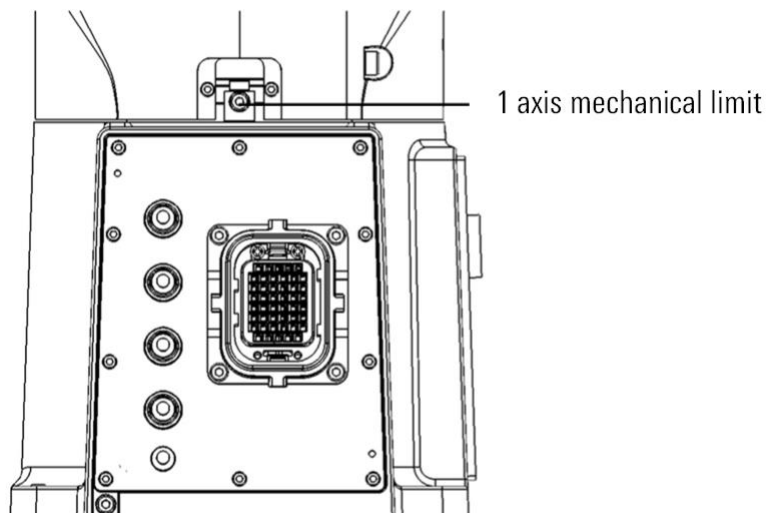


Figure 6-2 AIR4-560A mechanical brake on manipulator



Caution

Do not modify the mechanical brake. Otherwise the robot may not stop properly.

## 6.2.3 Stop method

According to GB5226.1-2008 "Mechanical and Electrical Safety - Part 1: General Technical Conditions" 9.2.2, the stop function definition is defined, and combined with the specific design of the robot, three stop modes are defined and corresponding explanations are shown in Table 6-2:

Table 6-2 Stop method and corresponding instructions

| Type  | Explain   |  |
|-------|---|--|
| STOP0 | Case1   | CCB alarm stop0 indicate, DCB execution immediately stops without maintaining trajectory, and then CCB delay control cuts off power through the main circuit relay control signal, which is an uncontrollable stop |
|       | Case2   | DCB has an uncontrollable fault that triggers a free stop or brake stop, which is considered an uncontrollable stop  |
|       | Case3   | Sudden external power outage, DCB unable to execute immediate stop, triggering brake stop, which belongs to uncontrollable stop  |
| STOP1 | Quickly stop the robot, maintain the current planned path, and when the robot stops, control the driver servo_Off and cut off the power supply through the main circuit relay, which is a controllable stop |  |
| STOP2 | Make the robot stop quickly and maintain the current planned path. When the robot stops, do not servo_off, does not cut off the power supply, belongs to controllable stop                                  |  |

## 6.3 Calibration

### 6.3.1 When calibration is required

The manipulator needs to be recalibrated when the following situations occur:

- Repair such as motor replacement or belt pulley removal.
- Replace the encoder battery.
- The encoder wire of the motor is loose or reinstalled.
- The manipulator has a strong collision.
- Replace the control cabinet or control system (e.g. industrial personal computer).

### 6.3.2 Calibration position of each axis

The position of each axis of the manipulator is shown in Figure 6-3 below, in which, except for the J3 axis, it is 90 °, and the other axes are 0 °.

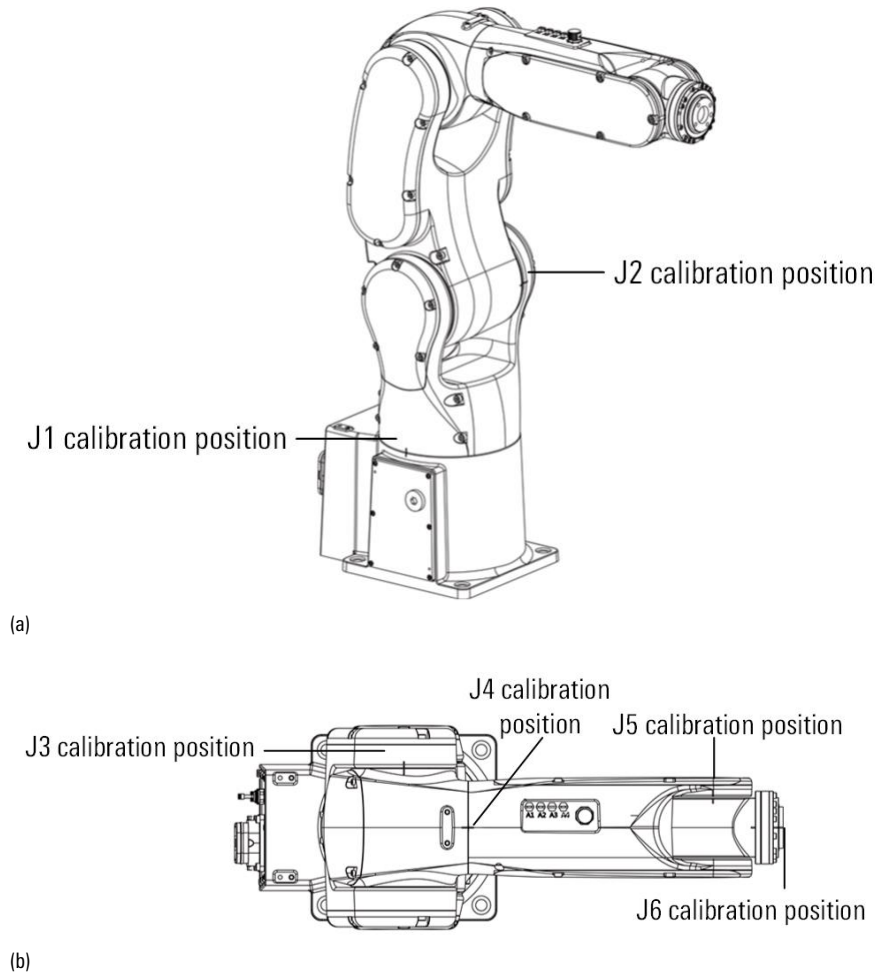



Figure 6-3 Diagram of zero points for each axis of AIR4-560A

|  |   |
|--|---|
| <br>Caution | <ul style="list-style-type: none"> <li>■ The robot calibration must always be performed at the same temperature conditions to avoid errors due to thermal expansion and contraction.</li> <li>■ The AIR4-560A industrial robot calibration must be calibrated in sequence from the J1 axis to the J6 axis.</li> </ul> |
|--|---|

**Calibration required for high repetitive positioning accuracy**

During the operation of the manipulator, only when it is required to have higher repeat positioning accuracy, the positioning accuracy of the path shall not be required. According to the zero point calibration position shown in Figure 6-3, the naked eye shall be used to make the zero point position of each axis to be aligned, as shown in Figure 6-4.

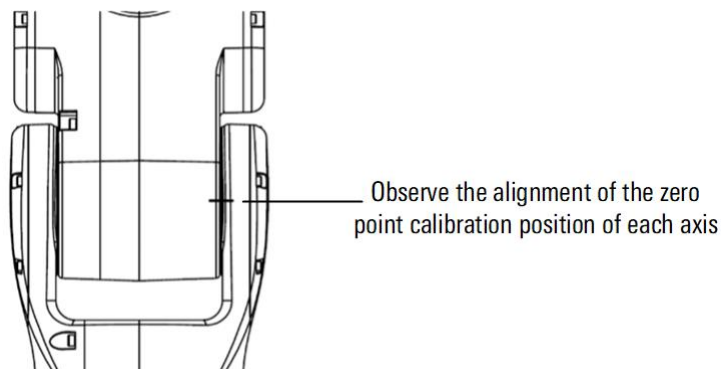



Figure 6-4 Calibration method of naked eye observation zero

|  |  |
|--|--|
| <br>Warning | In the calibration process of the manipulator, the speed should be reduced as much as possible, and the operator should not enter the working range of the robot. After each time the robot stops moving, the alignment of the zero scale on the axis position should be observed. |
|--|--|

### Calibration for high path positioning accuracy required

When the manipulator requires high path positioning accuracy, it is necessary to accurately calibrate and compensate the angle and length of each axis. You must contact our company to use special equipment for calibration.

### 6.3.3 Movement direction of each axis

For a 6-degree-of-freedom industrial robot manipulator, its movement direction is defined as shown in Figure 6-5. The J2, J3, and J5 axes are positive clockwise and counterclockwise are negative; when viewed from above, the J1, J4, and J6 axes are positive counterclockwise and clockwise are negative.

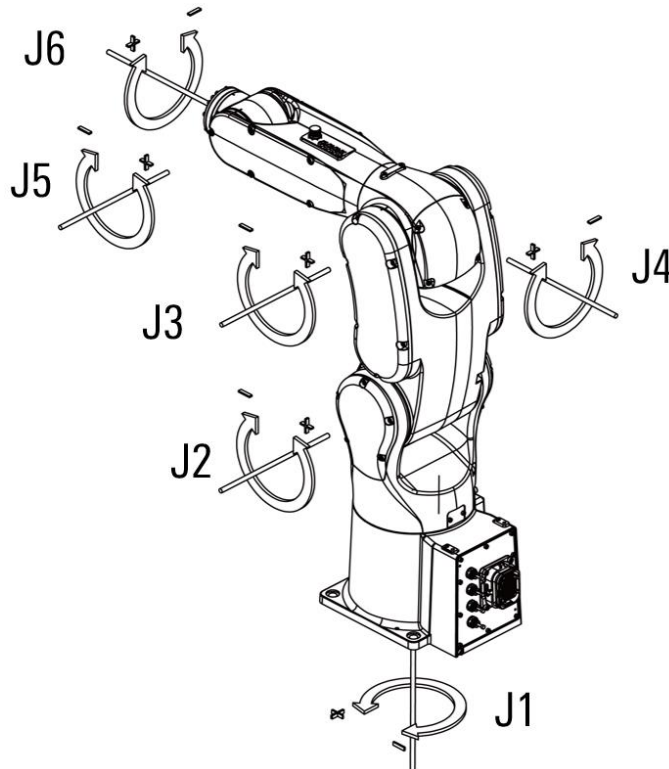


Figure 6-5 Movement direction of each axis of the manipulator

### 6.3.4 Speed of each axis

The maximum angular speed of each axis of the AIR4-560A manipulator is shown in Table 6-3.

Table 6-3 Maximum angular speed of each axis of the AIR4-560A manipulator

| Axis No. | Maximum angular velocity (° /s) |
|----------|---------------------------------|
| J1       | 450                             |
| J2       | 450                             |
| J3       | 525                             |

| Axis No. | Maximum angular velocity (° /s) |
|----------|---------------------------------|
| J4       | 600                             |
| J5       | 600                             |
| J6       | 800                             |

## 6.4 Output flange size

The output flange connection dimensions and diagram of the AIR4-560A manipulator are shown in Table 6-4 and Figure 6-6. For the screw tightening torque, please refer to Appendix B screw strength and screw tightening torque table (Nm).

Table 6-4 AIR4-560A output mechanical interface specifications

| Parameter                                      | Illustrate     |
|--|----------------|
| Locating circle diameter                       | 20mm           |
| Diameter of graduation circle of threaded hole | 31.5mm         |
| Screw grade                                    | 12.9           |
| Screw diameter                                 | M5             |
| Screw quantity                                 | 4              |
| Locating pin                                   | 5mm            |
| Screw standard                                 | GB/T 70.1-2008 |

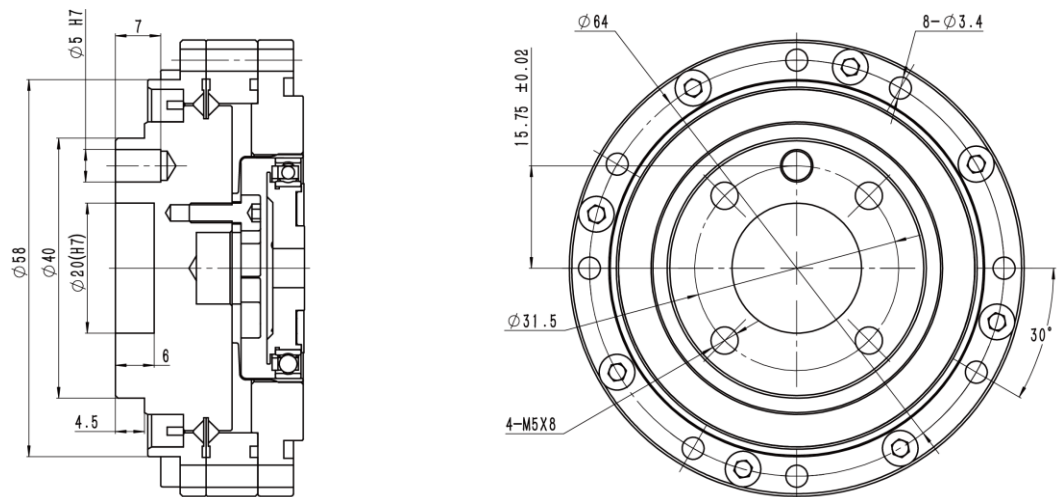


Figure 6-6 Diagram of wrist flange dimensions of AIR4-560A manipulator



When installing the fixture, the depth of the threaded hole and pin hole shall be fully considered for the screws and locating pins used. It is forbidden to install the length beyond the depth of the threaded hole (8mm) and the depth of the pin hole (7mm), otherwise the wrist of the manipulator will be damaged.

## 6.5 load installation

### Moment of inertia calculation method

The moment of inertia refers to how difficult it is for the load (end of fixture + workpiece) to rotate when the robot joint starts to rotate (the amount of inertia). The moment of inertia increases with load weight and eccentricity. Since this will also increase the load on the joints, make sure the moment of inertia is within the allowable value range.

Through the following formula, the moment  $M$  (N·m) and inertia moment  $I$  (kgm<sup>2</sup>) can be obtained when the load (end of fixture + workpiece) is small.

$$M(N \cdot m) = m(kg) \times L(m) \times g(m/s^2)$$

$$I(kgm^2) = m(kg) \times L^2(m)$$

Among them,  $M$  is the load weight (kg),  $L$  is the load eccentricity (m), and  $g$  is the gravity acceleration (m/s<sup>2</sup>).

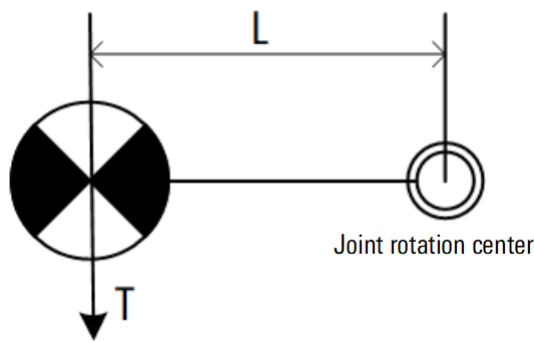


Figure 6-7 Load eccentricity diagram

### Installation of wrist load on the manipulator


Installation requirements:

- The load conditions should be within the range shown in Figure 6-8 and Table 6-5.
- The 4th axis allows a wrist torque less than 4.7Nm, the 5th axis allows a wrist torque less than 4.7Nm, and the 6th axis allows a wrist torque less than 2.9Nm.
- The 4-axis allows a load moment of inertia less than 0.057kgm<sup>2</sup>, the 5-axis allows a load moment of inertia less than 0.057kgm<sup>2</sup>, and the 6-axis allows a load moment of inertia less than 0.017kgm<sup>2</sup>.
- The allowable load moment of inertia of the 4-axis is less than 0.14kgm<sup>2</sup>, the allowable load moment of inertia of the 5-axis is less than 0.14kgm<sup>2</sup>, and the allowable load moment of inertia of the 6-axis is less than 0.11kgm<sup>2</sup>.

Table 6-5 AIR4-560A manipulator load torque and load moment of inertia data

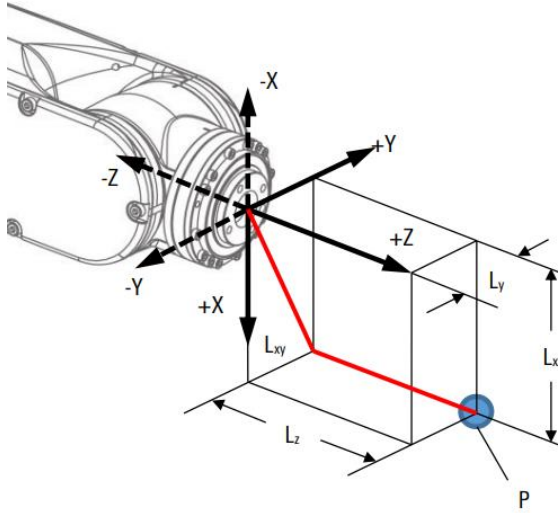
| Manipulator model | Axis | Load torque | Rated load moment of inertia | Maximum moment of inertia |
|-------------------|------|-------------|------------------------------|---------------------------|
| Wrist load 4kg    |      | Nm          | kgm <sup>2</sup>             | kgm <sup>2</sup>          |
| AIR4-560A         | J4   | 4.7         | 0.057                        | 0.14                      |
|                   | J5   | 4.7         | 0.057                        | 0.14                      |
|                   | J6   | 2.9         | 0.017                        | 0.11                      |



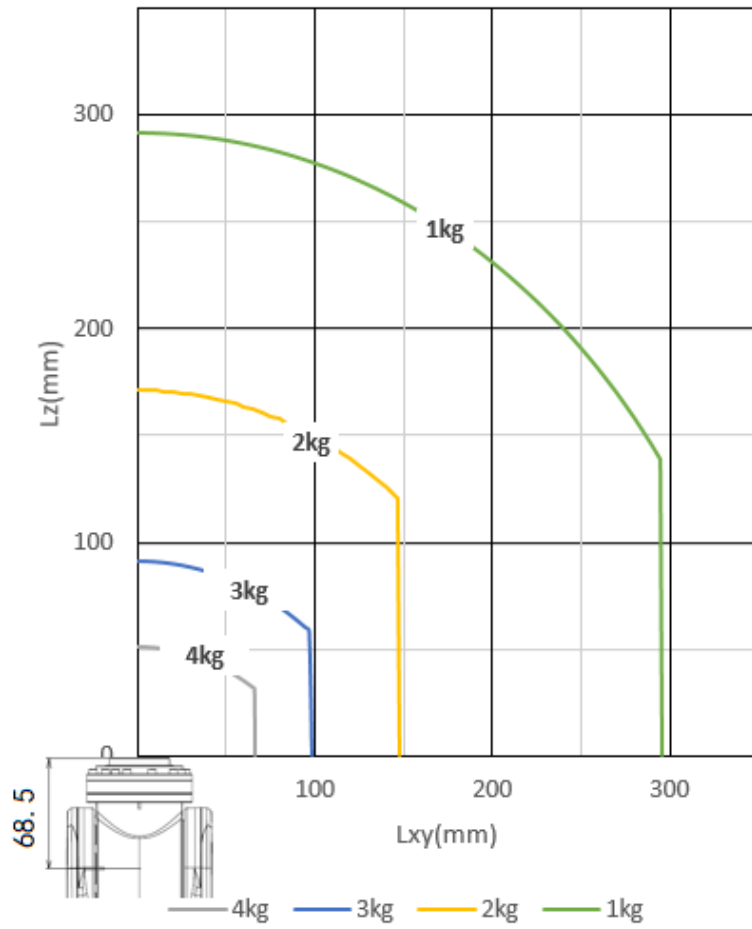


Prompt

The data in Table 6-5 show the load torque and moment of inertia corresponding to J4, J5, and J6 under rated operating conditions when a 4kg load ( $L_z=31.5\text{mm}$ ,  $L_{xy}=66\text{mm}$ ) is installed on the wrist; The maximum moment of inertia is the data when the load is 4kg.



(a)



(b)

Figure 6-8 Diagram of AIR4-560A wrist load centroid position

### Installation of 3-axis elbow equipment for the manipulator

Installation requirements:

- The AIR4-560A manipulator can install external devices weighing no more than 1kg at the elbow. As shown in Figure 6-9.
- The center of mass of the elbow load should be located inside the 20X70mm area shown in Figure 6-10.
- The height of the center of mass from the installation surface shall not exceed 30mm.

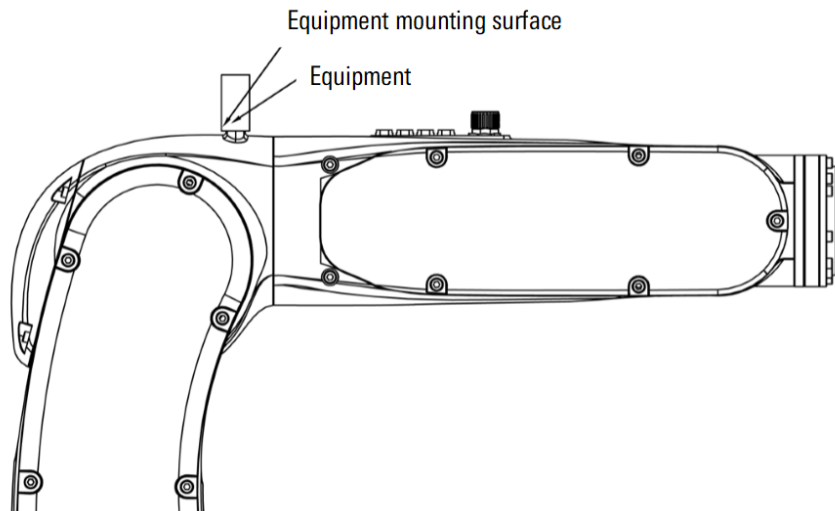


Figure 6-9 Diagram of installation dimensions for the elbow load of AIR4-560A manipulator

The specifications and dimensions of the three-axis elbow load installation hole for the AIR4-560A manipulator are shown in Figure 6-10 below.

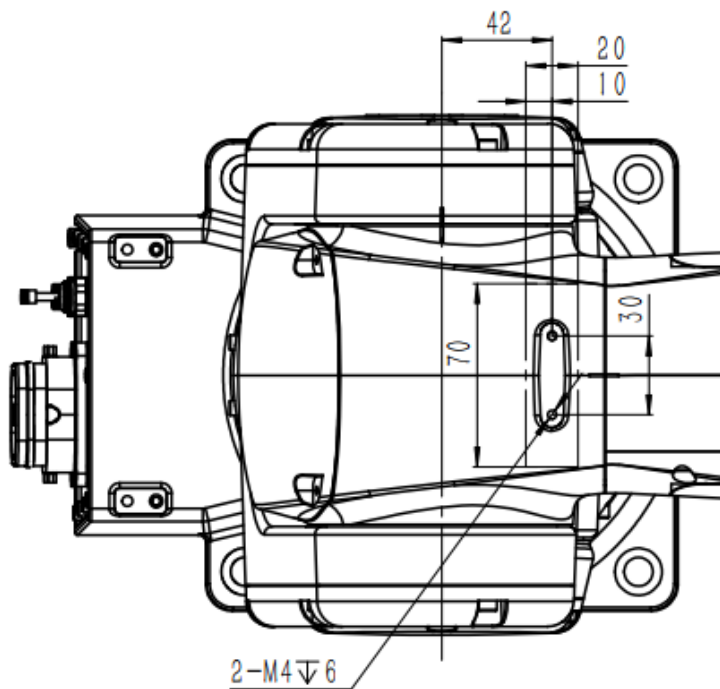


Figure 6-10 Diagram of the size of the elbow load interface of the AIR4-560A manipulator



- When installing the equipment, full consideration must be given to the reliability of the installation. It is recommended to use 12.9 grade screws to install them according to the specified torque, and apply thread glue to the threads. Otherwise, they may loosen or even break during long-term operation, causing accidents.
- Never add machined holes or screw holes to the main body of the manipulator because it may adversely affect the safety and functionality of the manipulator.
- When installing equipment, the screws used should fully consider the depth of the threaded hole. It is prohibited to install the length beyond the depth of the threaded hole (10mm), otherwise the elbow of the operator will be damaged.
- The center of mass of the elbow load must not exceed the above values, otherwise the manipulator may alarm, fail to work normally, or reduce its working life.
- When installing equipment on the elbow of the manipulator, be careful to avoid interference with the manipulator and cables, which may cause the cables to break and lead to unexpected serious faults and consequences.



## 7 Transportation and handling

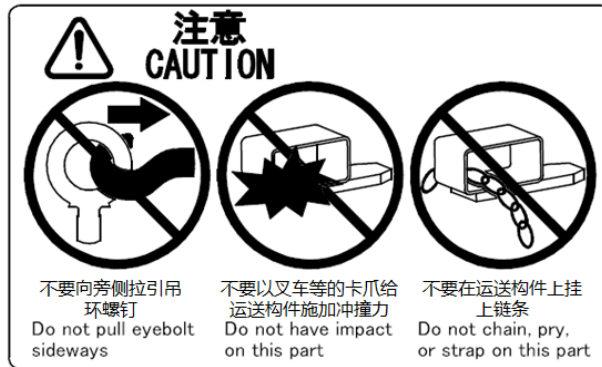
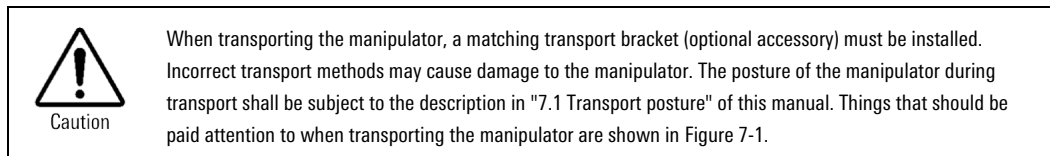


Figure 7-1 Precautions when transporting the manipulator

### 7.1 Transport attitude

The postures of one to six axes when handling the AIR75-2100B are as shown in Table 7-1.

Table 7-1 Angle value of each axis during robot transportation

| A1 | A2   | A3   | A4 | A5  | A6 |
|----|------|------|----|-----|----|
| 0  | -25° | 152° | 0  | 53° | 0  |

Please see Figure 7-2 for the rendering of the one to six-axis attitude of the AIR75-2100B when being transported.

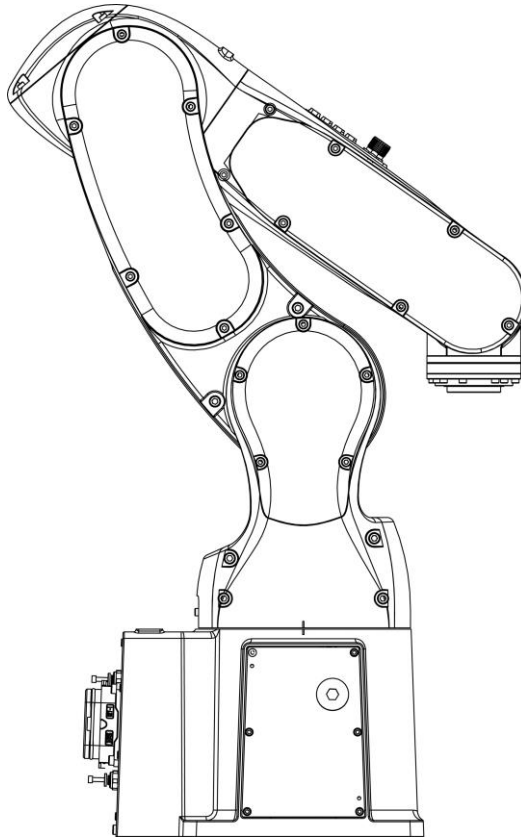


Figure 7-2 AIR4-560A manipulator handling posture diagram



Caution

- The manipulator must strictly follow the posture in Table 7-1 when transporting it, otherwise it may tip over due to unstable center of gravity.
- When the manipulator is transported over long distances, a wooden support must be added between the forearm and the two-axis reducer casting to reduce the impact load during transportation. The wood and the support points are separated by soft mats to prevent the wood from scratching the surface of the manipulator.

## 7.2 Transport dimensions

Please refer to Figure 7-3 for the dimensions that each part of the manipulator needs to meet when it is being transported.

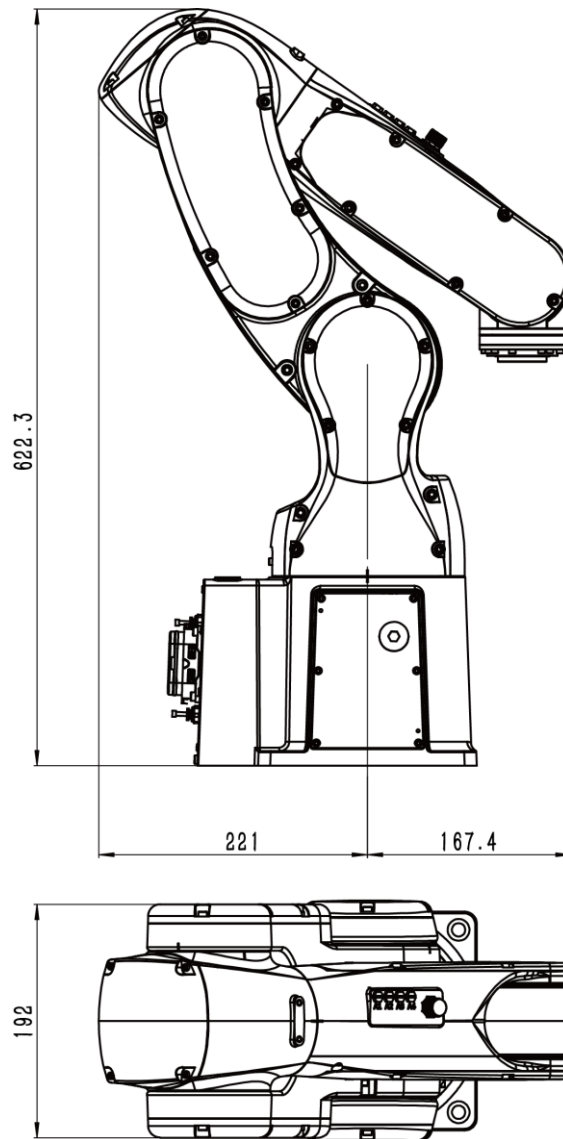


Figure 7-3 AIR4-560A handling manipulator dimensions



Caution

The actual size may be slightly larger than the size in Figure 7-3, please note.

## 7.3 Handling method

### Forklift transportation

The diagram when using a forklift to transport is as shown in Figure 7-4. The forklift should be able to meet the weight requirement of the manipulator (23kg), and the total weight of the manipulator and the handling device is about 31kg.



Caution

When transporting the manipulator, a matching transport bracket (optional accessory) must be installed. Incorrect transport methods may cause damage to the manipulator. The posture of the manipulator during transport shall be subject to the description in "7.1 Transport posture" of this manual.

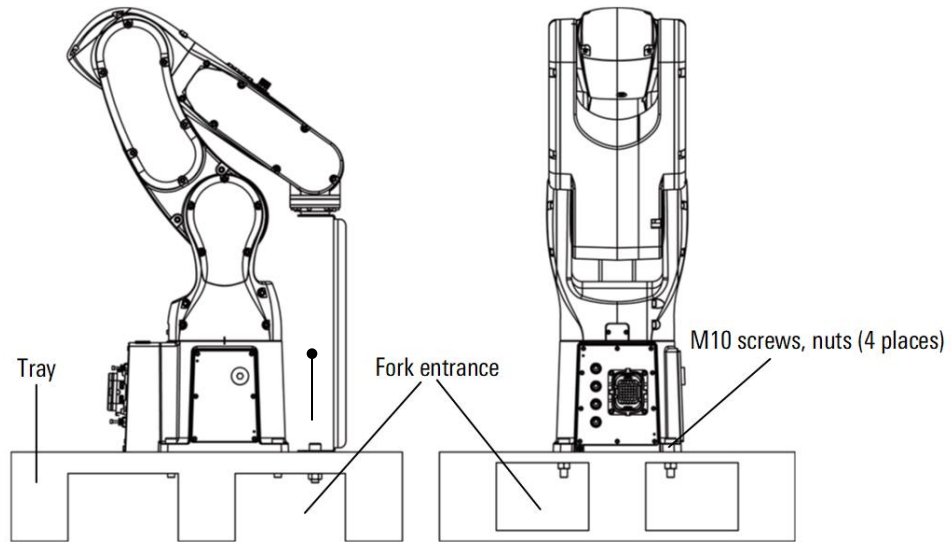



Figure 7-4 AIR4-560A forklift handling diagram

### Ring handling

The diagram when the manipulator is transported using a lifting ring is shown in Figure 7-5 below. The lifting device should be able to meet the weight requirement of the manipulator (23kg). The total weight of the manipulator and transporting device is about 50kg.

A single sling can carry a weight of more than 150kg, and a crane can carry a weight of more than 200kg.

|  |   |
|--|---|
| <br>Caution | <ul style="list-style-type: none"> <li>■ When the manipulator is transported using a lifting ring, insert a soft object between the contact area between the lifting rope and the manipulator to prevent the lifting rope from scratching the manipulator.</li> </ul> |
|  | <ul style="list-style-type: none"> <li>■ The manipulator may tip over when transported using lifting rings. Please be particularly careful to keep the manipulator stable during transportation.</li> </ul>   |
|  | <ul style="list-style-type: none"> <li>■ Do not pull the lifting ring sideways to avoid damage to the manipulator and unexpected malfunctions.</li> </ul>   |

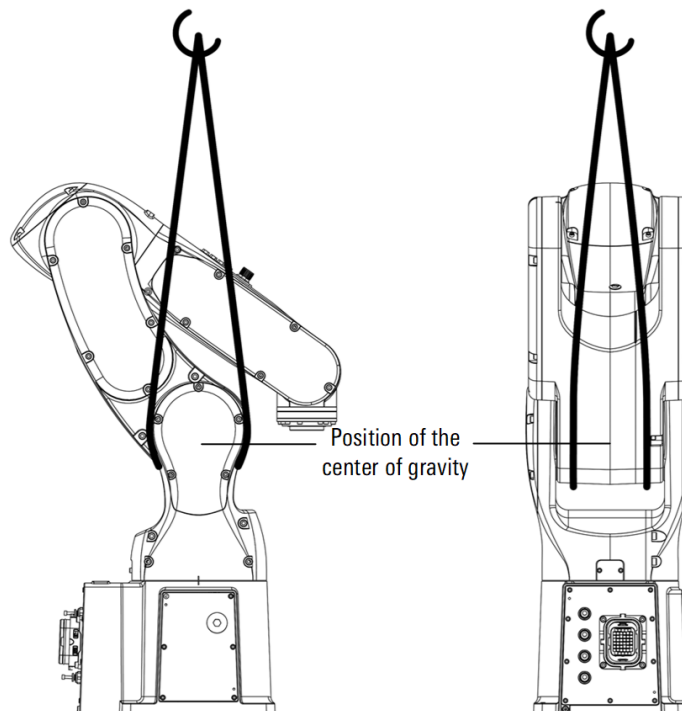


Figure 7-5 AIR4-560A lifting ring handling diagram



## 8 General principles of maintenance

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This manual provides instructions for preventive maintenance of the AIR4-560A manipulator. For a complete industrial robot system maintenance, it should also include:

- For the maintenance of the control cabinet, please refer to the company's "inCubeXX Control Cabinet Manual".
- For end effector maintenance, please refer to the relevant manuals (i.e., the relevant manuals for the end effectors provided by the user).



- Never perform any maintenance work before reading the general safety instructions and safety precautions, and maintenance work can only be completed by appropriately trained technicians.
- The primary goal of preventive maintenance is to ensure maximum utilization of the manipulator system. Every scheduled and properly performed periodic maintenance should help achieve this goal. If scheduled maintenance does not achieve the goal of reducing unit downtime, it is unnecessary and wasteful maintenance.
- Robotic systems are designed to work under quite demanding conditions and require minimal maintenance. Nonetheless, daily inspections and periodic maintenance must be carried out at given intervals.
- The time intervals in the maintenance table are recommended values. The actual time intervals required to maintain the manipulator may vary due to factors such as the actual working environment of the manipulator.
- When performing routine repairs or maintenance, numerous precautions must be kept in mind to avoid introducing additional errors or dangers into the system.
- Do not perform more scheduled maintenance than required on equipment that is operating well.
- All surfaces should be wiped clean before starting maintenance procedures.
- In order to avoid unnecessary contamination caused by dust and other debris, the outside of the control cabinet door and manipulator cover should be cleaned before opening them.



## 9 Preventive maintenance

### 9.1 Safety protection measures

#### Precautions during maintenance



Warning

- When the power is turned on, there is a danger of electric shock in part of the maintenance operations. The maintenance operations should be performed with the manipulator and system power off as much as possible; professional maintenance personnel should be designated as needed to perform maintenance operations; other personnel should be avoided during maintenance operations. Turn on the power; even in the case where the power must be turned on before the work can be performed, press the emergency stop button before proceeding.
- When you need to replace parts, please consult our company.
- The customer's independent replacement of parts may cause unexpected accidents, damage the manipulator, and cause injury to the operators.
- If you need to replace parts, be sure to use the parts designated by our company. If parts other than the specified parts are used, it may cause damage to the manipulator.
- When disassembling the motor and brake, take measures such as lifting by a crane before dismantling, so as to prevent the manipulator arm from falling
- During maintenance operations, when the manipulator needs to be moved due to unavoidable circumstances, the following items should be noted:
  - Make sure that the escape route is unblocked, and you should perform operations after you have grasped the operation of the entire system to avoid blocking the exit route by the manipulator and peripheral equipment
  - Always pay attention to whether there are dangers around and be prepared so that you can press the emergency stop button at any time when needed
- When moving parts with a certain weight such as motors and reducers, auxiliary equipment such as cranes should be used to avoid excessive work burdens on operators. At the same time, it is necessary to avoid wrong operation, otherwise it may cause injury or death of the operator.
- Be careful not to fall down because of the lubricating oil spilled on the ground. Wipe off the lubricating oil on the ground as soon as possible to eliminate possible dangers.
- During the operation, do not put any part of the body on any part of the manipulator, and it is forbidden to climb on the manipulator to avoid unnecessary personal injury or adverse effects on the manipulator.
- The following parts will generate heat, so be careful. When it is necessary to touch the device under heat, you should prepare protective equipment such as heat-resistant gloves:
  - Servo motor
  - Reducer
  - Components adjacent to the motor/reducer
  - Inside the control cabinet
- The parts (such as screws, etc.) that are removed when replacing parts should be correctly installed back to their original positions. If parts are found to be insufficient or there are remaining parts, they should be reconfirmed and installed correctly.
- When repairing the pneumatic system and hydraulic system, be sure to release the internal pressure to 0 before proceeding.
- When replacing parts, avoid dust and other foreign objects from entering the inside of the manipulator.

- Operators who perform maintenance and repair operations must be trained by our company and pass relevant assessments.
- Appropriate lighting equipment should be equipped for maintenance work, but care should be taken not to make the lighting equipment the source of new hazards.
- Please refer to this manual for regular maintenance. Failure to perform regular maintenance will affect the service life of the manipulator and may result in accidents.

## Safety of maintenance engineers

In order to ensure the safety of maintenance engineers, the following items should be fully paid attention to:

- During the operation of the manipulator, do not enter the operating range of the manipulator.
- Carry out maintenance work with the power supply of the control device disconnected as much as possible. The main circuit breaker should be locked with a lock, etc. as needed to prevent other people from turning on the power.
- When it is necessary to enter the working range of the manipulator during power-on, you should press the emergency stop button of the control cabinet or the teach pendant before entering. In addition, the operator should put up a "maintenance operation" sign to remind other personnel not to operate the manipulator at will.
- Before performing maintenance work, confirm that the manipulator or peripheral equipment is in a safe state.
- Do not perform automatic operation when there are people in the operating range of the manipulator.
- When working near walls, appliances, etc., or when several operators are close, be careful not to block the escape passages of other operators.
- When there are knives on the manipulator, and when there are moving devices such as conveyor belts in addition to the manipulator, pay full attention to the actions of these devices.
- A person who is familiar with the manipulator system and can detect the danger should be arranged beside the operation panel and operation box during operation, so that they can press the emergency stop button at any time.
- When replacing parts or reassembling, pay attention to avoid foreign matter adhesion or mixing.
- When inspecting and repairing the inside of the control device, if you want to touch the unit, printed circuit board, etc., in order to prevent electric shock, be sure to disconnect the power supply of the main circuit breaker of the control device before proceeding.
- The replacement parts must use the parts designated by our company.
- When restarting the manipulator system after the maintenance work is completed, fully confirm in advance that no one is within the operating range of the manipulator, and that the manipulator and peripheral equipment are in normal state.

## 9.2 Daily maintenance

When operating the manipulator every day, check the items shown in Table 9-1.

Table 9-1 Daily maintenance items of the manipulator

| No. | Check item                                     | Check essentials   |
|-----|--|--|
| 1   | Vibration, sound, motor heating                | Whether there is abnormal vibration or noise on each axis, and whether the motor temperature is abnormally high. |
| 2   | Whether the positioning accuracy changes       | Check whether it deviates from the last start position and whether there is a deviation in the stop position     |
| 3   | Operation confirmation of peripheral equipment | Confirm that the actions of the manipulator and peripheral equipment are consistent with the instructions        |

## 9.3 First maintenance

The manipulator shall run for the first time 320 hours or 1 month (whichever is shorter), and the following items shall be inspected and maintained. As shown in Table 9-2:

Table 9-2 Manipulator first maintenance project

| No. | Inspection item  | Main points of inspection   |
|-----|--|---|
| 1   | Whether the cable and cable sheath of the manipulator are damaged differently and whether the motor connector is loose | Observe the cable activity part of the manipulator, check whether the cable is damaged, whether the cable is bent or distorted locally, check whether the cable sheath is damaged or not, and check whether the motor connector is loose (Note 1) |
| 2   | Tighten the main external bolts  | Use a torque wrench to tighten the end effector mounting bolts and the main external bolts (see note 2 for the method)  |
| 3   | Clean all parts of the manipulator   | Clean and maintain the parts of the manipulator, and check whether the parts are damaged (Note 3).  |
| 4   | Whether the end effector cable is damaged  | Check whether the cable is damaged and whether the cable sheath is damaged.   |
| 5   | Whether the timing belt is worn  | Check the timing belt for wear, elongation, and breakage (Note 4)   |
| 6   | Check whether the limit rubber blocks at the J1 axis is damaged.   | Check whether the limit rubber block is loose, damaged by collision, aging, etc.  |

Note 1:

#### Check and Repair Points

- Cables and cable sheaths inside the manipulator base (the electrical installation plate needs to be removed).
- The internal cables and cable sheaths between the manipulator boom and the J1 axis body.
- Manipulator connection cables, ground terminals, and user cable connectors.

#### Confirmation

- Check the line sheath for cracks and wear. If the sheath is damaged, replace it.
- Check whether the grease on the surface of the cables inside the J1 axis body and the cables inside the boom has disappeared. If the grease is about to disappear, replenish it.
- Check whether the wiring is worn, and if the internal wires are visible, replace them.
- Circular connector: Turn it by hand to see if it is loose.
- Square heavy load: Confirm whether the control rod has fallen off.
- Ground terminal: Check whether it is loose.

Note 2:

#### Fastening part

- Tighten the end effector mounting bolts, manipulator fixing bolts, etc.
- The external connection screws of the manipulator, especially the connection screws of each axis and the reducer.
- For tightening torque, please refer to the recommended values in the appendix of this manual.

Note 3:

#### About cleaning

- Regarding the parts that need to be cleaned and the accumulation of dust and splash on the surface, they should be cleaned regularly.

- Special attention needs to be paid to cleaning between the rotating parts of the J5 axis of the wrist, and debris should be removed in a timely manner.
- Confirm if there is oil leaking from the reducer or gear box.
- After wiping off the oil, if the oil is still visible after 1 day, there may be an oil leak.

Note 4:

About timing belt maintenance

- After removing the manipulator cover, observe whether the timing belt is worn or damaged. To remove the cover, please refer to "10.4 Replacing the Timing Belt" in this manual.
- Observe whether there is white hair inside the teeth of the timing belt, whether the belt side is worn, whether the belt teeth are crushed, whether the belt body is broken, whether the belt body is stretched (decreased preload), etc.

## 9.4 Regular maintenance

### Regular maintenance for 960h (3 months)

The following check and repair items shall be done for manipulator after the 960h or 3 months (whichever comes first). As shown in Table 9-3.

Table 9-3 Maintenance Items for 960 h (3 months)

| No. | Check Item                       | Essentials  |
|-----|----------------------------------|---|
| 1   | Cleaning of control cabinet vent | Remove the dust accumulated at control cabinet vent                   |
| 2   | Cleaning of manipulator          | Wipe off the dirt and remove the accumulated splash, dust, chip, etc. |

### Regular maintenance for 1,920h (6 months)

The following check and repair items shall be done for manipulator after the 1,920 h or 6 months (whichever comes first). As shown in Table 9-4.

Table 9-4 Maintenance Items for 1,920 h (6 months)

| No. | Check Item   | Essentials                               |
|-----|--|--|
| 1   | Check whether the manipulator cable and cable sheath are damaged | See the first maintenance in Chapter 9.3 |

### Regular maintenance for 3,840h (1 year)

The following check and repair items shall be done for manipulator after the 3,840h or 1 year (whichever comes first). As shown in Table 9-5:

Table 9-5 Maintenance Items for 3,840 h (1 year)

| No. | Check Item   | Essentials                                      |
|-----|--|---|
| 1   | Check whether the manipulator cable and cable sheath are damaged | See the first maintenance in <i>Chapter 9.3</i> |

| No. | Check Item  | Essentials                                      |
|-----|---|---|
| 2   | Tighten the main external bolts                         | See the first maintenance in <i>Chapter 9.3</i> |
| 3   | Clean all parts of the manipulator                      | See the first maintenance in <i>Chapter 9.3</i> |
| 4   | Whether the end effector cable is damaged               | See the first maintenance in <i>Chapter 9.3</i> |
| 6   | Check whether the J1 axis limit rubber block is damaged | See the first maintenance in <i>Chapter 9.3</i> |

### Regular maintenance for 7,860 h (2 years)

The following check and repair items shall be done for manipulator after the 7,860h or 2 years (whichever comes first).

As shown in Table 9-6:

Table 9-6 Maintenance Items for 7,860 h (2 years)

| No. | Check Item          | Essentials                                       |
|-----|---------------------|--|
| 1   | Battery Replacement | See <i>the first maintenance in Chapter 10.3</i> |

### Regular maintenance for 15,360h (4 years)

The following check and repair items shall be done for manipulator after the 15,360 h or 4 years (whichever comes first).

As shown in Table 9-7:

Table 9-7 Maintenance Items for 15,360 h (4 years)

| No. | Check Item                                 | Essentials  |
|-----|--|---|
| 1   | Replace the internal cables of manipulator | Replace the manipulator cable, please consult with us |

### Regular maintenance for 19,200h (5 year)

The manipulator shall be overhauled with many parts replaced for 5 years or 192,000 h (whichever comes first). Please contact us. As shown in Table 9-8:

Table 9-8 Maintenance Items for 19,200 h (5 years)

| No. | Check Item           | Essentials             |
|-----|----------------------|------------------------|
| 1   | Manipulator overhaul | Please consult with us |





## 10 Project maintenance process

### 10.1 Cleaning the manipulator

In order to ensure the long-term operation of the robot, the manipulator should be cleaned regularly every 960 hours or 3 months of operation (whichever is shorter).

Cleaning steps:

Step1.Adjust the robot to calibration state.

Step2.To prevent danger, turn off the power, hydraulic and air pressure sources connected to the robot.

Step3.Use a vacuum cleaner to clean the manipulator, or wipe with a cloth.

Step4.After ensuring that all safety conditions are met, proceed with the follow-up work of the manipulator.



- It is forbidden to use water jet on the manipulator, especially the joints and seals.
- It is forbidden to use compressed air to clean the manipulator.
- It is forbidden to remove any manipulator protection device
- It is forbidden to use solvents to clean the manipulator

### 10.2 Check and repair cables

To ensure the long-term operation of the robot, the manipulator cable should be checked every 1920 hours or 6 months of operation (whichever is shorter).

Repair the internal cables of the base

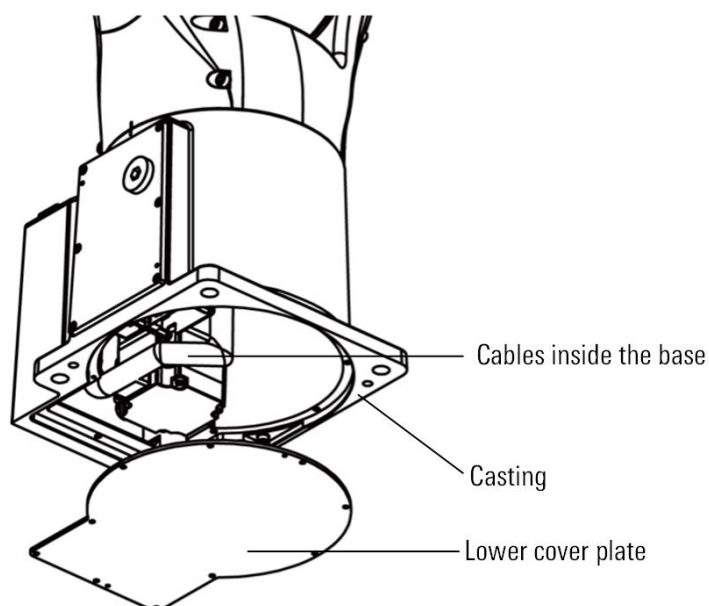


Figure 10-1 Cable inside the base

Maintenance steps:

- Step1.Remove the lower cover plate of the base, as shown in Figure 10-1, and pull out the internal cables of the base.
- Step2.Check if the bracket securely secures the cables to the manipulator.
- Step3.Check if there is wear or damage at the fixing point of the cable and bracket.
- Step4.Check if there is any wear or damage to the internal cables.
- Step5.If there are cracks, wear or damage, please contact our company for replacement in a timely manner.
- Step6.Install the cables inside the base.
- Step7.Install the base lower cover, and apply sealant to the joint surface of the base lower cover and the base casting.

### Inspect the internal cables of J1 and J2 axes

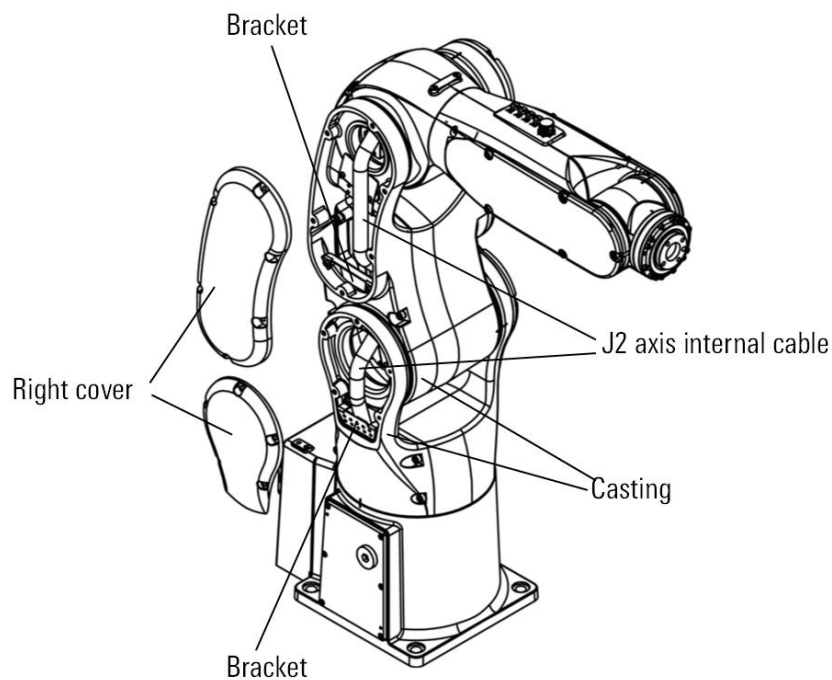


Figure 10-2 J1, J2 axis internal cables

#### Maintenance steps:

- Step1.Remove the right cover, as shown in Figure 10-2, and pull out the internal cables of the J1 and J2 axes.
- Step2.Check if the bracket securely fastens the cable to the manipulator.
- Step3.Check if there is any wear or damage at the cable and bracket fixing point.
- Step4.Check if there is any wear or damage to the internal cables.
- Step5.If there are cracks, wear or damage, please contact our company for replacement in a timely manner.
- Step6.Install the cable into the manipulator.
- Step7.Install the right cover, and apply sealant to the joint surface between the cover and the casting.

## Inspecting the internal cables of the J3 axis

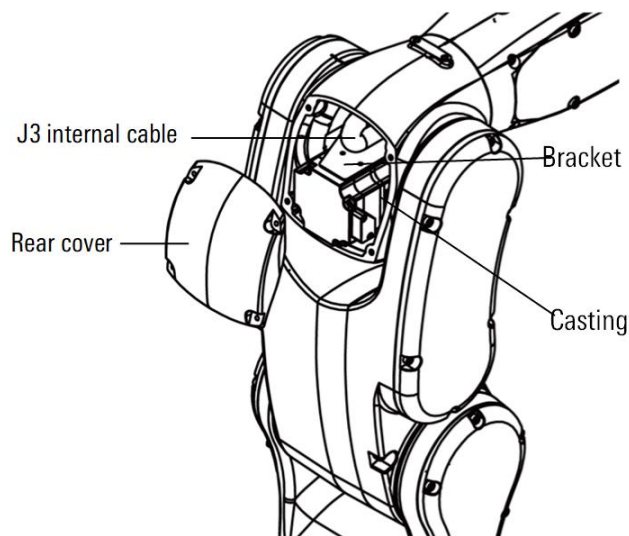


Figure 10-3 J3 axis internal cable

### Maintenance steps:

Step1.Remove the J3 axis rear cover, as shown in Figure 10-3 above, and pull out the J3 axis internal cables.

Step2.Check whether the bracket secures the cable to the manipulator intact.

Step3.Check if there is any wear or damage at the cable and bracket fixing point.

Step4.Check if there is any wear or damage to the internal cables.

Step5.If there are cracks, wear or damage, please contact our company for replacement in a timely manner.

Step6.Step to install the cable into the interior of the manipulator.

Step7.Install the J3 axis back cover plate and apply sealant on the mating surface between the J3 axis back cover plate and the casting.

## 10.3 Replacing the battery

The position data of each axis of the manipulator is saved by the encoder battery. The battery should be replaced promptly every 7860 hours or 2 years (whichever is shorter) of operation.

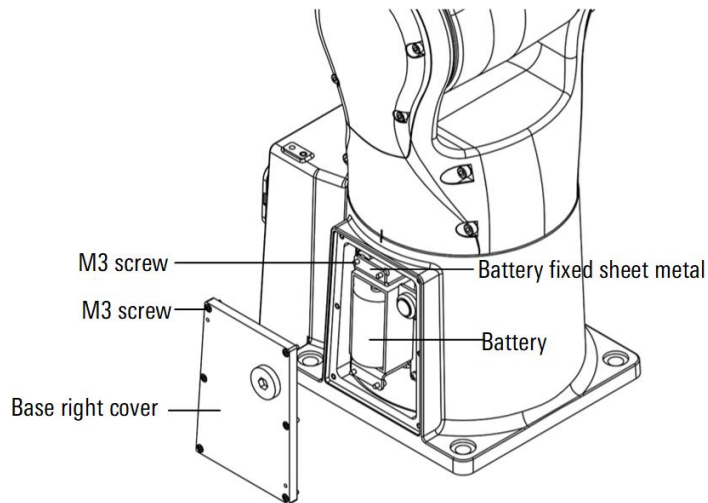


Figure 10-4 Replace the battery

Maintenance process:

Step1. Adjust the robot to the calibration state (move each axis to the calibration position, refer to section 6.3.2).

Step2. To prevent danger, turn off the power, hydraulic source, and air source connected to the robot.

Step3. Remove the right cover plate of the base, as shown in the above Figure 10-4.

Step4. Remove the battery fixing sheet metal, as shown in the above Figure 10-4.

Step5. Remove the old battery from the battery compartment and insert the new battery into the battery compartment, paying attention to the polarity of the battery.

Step6. Install battery fixing sheet metal and right cover plate of the base, and apply sealant on the mating surface between the right cover plate and the base casting.

Step7. After ensuring that all safety conditions are met, proceed with the manipulator calibration and testing work.

## 10.4 Replace timing belt

The J1, J3, J4, J5, and J6 synchronous belts of the operating machine need to be replaced every 3840 hours or 1 year (whichever is shorter).

For synchronous belt models, please refer to Table 10-1:

Table 10-1 Model of manipulator synchronous belt

| Synchronous belt position      | Model     |
|--------------------------------|-----------|
| Internal axis J1 of the base   | 297-3GT-6 |
| Inner J3 axis of the upper arm | 420-3GT-6 |
| Elbow inner J4 axis            | 204-3GT-6 |
| J5 axis inside the forearm     | 414-3GT-4 |

|                            |           |
|----------------------------|-----------|
| Synchronous belt position  | Model     |
| J6 axis inside the forearm | 297-3GT-4 |

When replacing the timing belt, please refer to Table 10-2 for the manipulator posture:

Table 10-2 Manipulator replacement synchronous belt posture

| J1  | J2 | J3  | J4 | J5  | J6  |
|-----|----|-----|----|-----|-----|
| Any | 0° | 90° | 0° | 90° | Any |

### Replace J3 axis synchronous belt

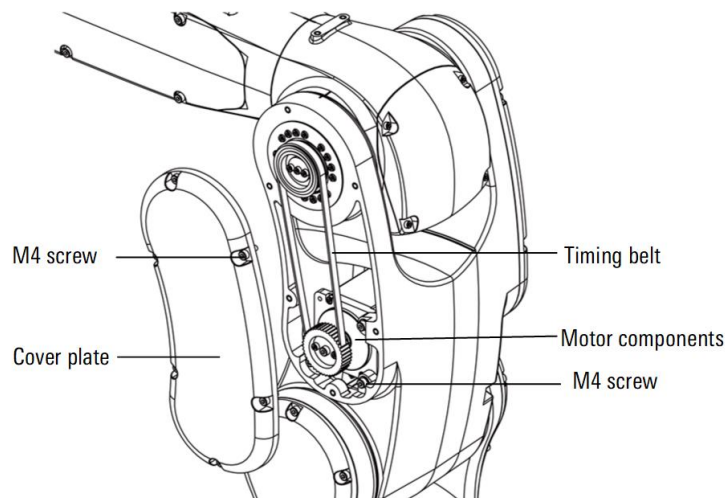


Figure 10-5 Diagram of J3 axis synchronous belt replacement

Maintenance process:

Step1.Run the manipulator to the posture shown in Table 10-2.

Step2.Cut off power to the control unit.

Step3.In order to prevent the rear axis from falling due to gravity after the timing belt is removed, the manipulator needs to be fixed.

Step4.Remove the manipulator cover and 6 screws, as shown in Figure 10-5.

Step5.Loosen the motor assembly mounting screws.

Step6.Move the motor pulley assembly, remove the old timing belt, and install the new timing belt.

Step7.Preliminarily tighten the motor base screws.

Step8.Adjust the screw position and adjust the synchronous belt to the appropriate down force. The recommended down force is 6N and the deflection is 5mm.

Step9.Install the motor base screws using the specified torque.

Step10.Install the manipulator cover and apply sealant to the joint.

Step11.Carry out the calibration of the J3 axis of the manipulator.

## Replace the J5 axis timing belt

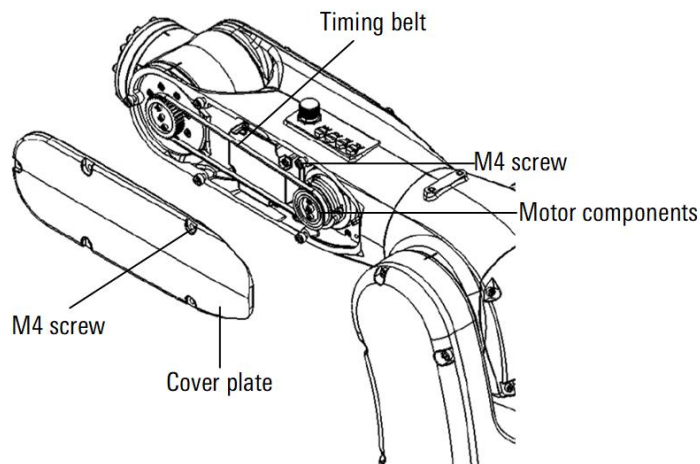


Figure 10-6 Diagram of J5 axis synchronous belt replacement

Maintenance process:

Step1.Run the manipulator to the posture shown in Table 10-2.

Step2.Cut off power to the control unit.

Step3.In order to prevent the rear axis from falling due to gravity after the timing belt is removed, the manipulator needs to be fixed.

Step4.Remove the manipulator cover and screws, as shown in Figure 10-6.

Step5.Loosen the motor assembly mounting screws.

Step6.Move the motor pulley assembly, remove the old timing belt, and install the new timing belt.

Step7.Preliminarily tighten the motor base screws.

Step8.Adjust the screw position and adjust the synchronous belt to the appropriate down force. The recommended down force is 4.2N and the deflection is 5mm.

Step9.Install the motor base screws using the specified torque.

Step10.Install the manipulator cover and apply sealant to the joint.

Step11.Carry out the calibration of the J5 axis of the manipulator.

## Replace the J6 axis timing belt

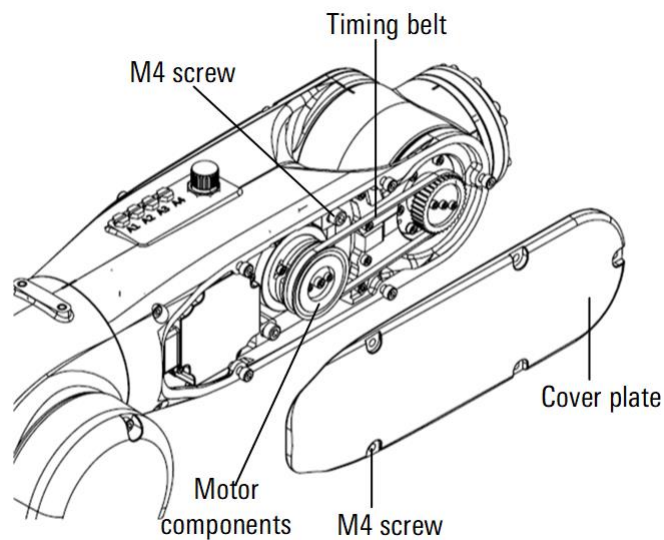


Figure 10-7 Diagram of J6 axis synchronous belt replacement

### Maintenance process:

Step1.Run the manipulator to the posture shown in Table 10-2.

Step2.Cut off power to the control unit.

Step3.In order to prevent the rear axle from falling due to gravity after the timing belt is removed, the manipulator needs to be fixed.

Step4.Remove the manipulator cover and screws, as shown in Figure 10-7.

Step5.Loosen the motor assembly mounting screws.

Step6.Move the motor pulley assembly, remove the old timing belt, and install the new timing belt.

Step7.Preliminarily tighten the motor base screws.

Step8.Adjust the position of the screw and adjust the synchronous belt to the appropriate down force. The recommended down force is 14N and the deflection is 5mm.

Step9.Install the motor base screws using the specified torque.

Step10.Install the manipulator cover and apply sealant to the joint.

Step11.Carry out the calibration of the J6 axis of the manipulator.

### Downforce and deflection

Please refer to Figure 10-8 for a diagram of downforce and deflection.

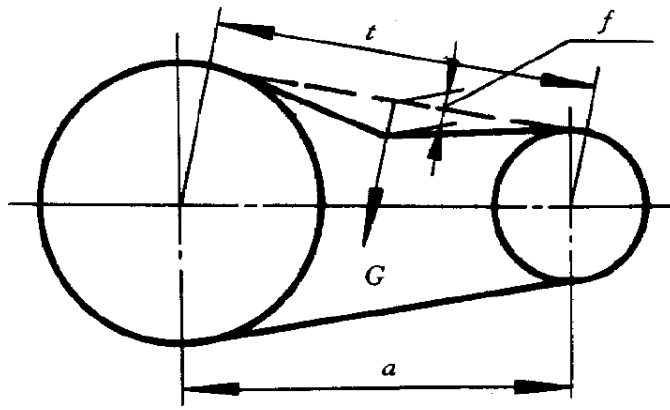


Figure 10-8 Diagram of downforce and deflection

Parameter explanation:

- $G$ —Downforce, unit N;
- $f$ —Deflection amount, unit mm.



## 11 Fault finding, diagnosis and repair

The malfunction of the manipulator is sometimes caused by multiple different reasons. It is often difficult to thoroughly investigate the cause. If the error handling method is adopted, the malfunction may be further deteriorated. Therefore, it is very important to analyze the malfunction in detail and find the real cause.

The possible faults and causes of the manipulator are shown in Table 11-1-Table 11-7. If you are not sure of the cause or how to deal with it, please contact our company.

Table 11-1 Possible faults and causes of manipulator

| Fault                       | Classification   | Possible Causes   | Treatment  |
|-----------------------------|--|---|--|
| Vibration<br>Abnormal noise | <ul style="list-style-type: none"> <li>■ When the manipulator operates, its base floats from the workshop pedestal</li> <li>■ There is a gap between the base and workshop pedestal</li> <li>■ The screws connecting the base and workshop pedestal are loose</li> </ul> | <p>Fixation of Base:</p> <ol style="list-style-type: none"> <li>1. The manipulator base is not firmly fixed on the workshop pedestal</li> <li>2. The base floats from the workshop pedestal and generates the vibration when the manipulator acts due to the screw looseness, insufficient flatness of base and the foreign objects.</li> </ol>                         | <ol style="list-style-type: none"> <li>1. When the screw is loose, tighten it with the torque wrench according to the proper torque</li> <li>2. Trim the base flatness in accordance with the tolerance</li> <li>3. Check if the foreign matters are trapped, and if so, remove them</li> <li>4. Please consult with us</li> </ol>   |
|                             | Workshop pedestal vibrates when the manipulator acts   | <p>Workshop Pedestal:</p> <ol style="list-style-type: none"> <li>1. Pedestal is not completely fixed on the foundation. Therefore, the workshop pedestal vibrates when the manipulator acts.</li> <li>2. The insufficient rigidity of workshop pedestal, and the reaction force and torque generated by the manipulator cause the deformation and vibration.</li> </ol> | <ol style="list-style-type: none"> <li>1. Completely fix the workshop pedestal according to the corresponding method</li> <li>2. Workshop pedestal shall be processed to improve its rigidity</li> <li>3. For the workshop pedestal with machining difficulty, the vibration may be mitigated through the modification of moving program</li> <li>4. Please consult with us</li> </ol> |

Table 11-2 Possible Faults and Causes of Manipulator

| Fault                       | Classification  | Possible Causes   | Treatment   |
|-----------------------------|---|---|---|
| Vibration<br>Abnormal noise | <ul style="list-style-type: none"> <li>■ Vibration at a specific posture during the action</li> <li>■ No vibration at the slow action</li> <li>■ Obvious vibration during acceleration and deceleration</li> <li>■ Simultaneous vibration of multiple axes</li> </ul> | <ol style="list-style-type: none"> <li>1. Load of manipulator exceeds the allowable value</li> <li>2. Action procedures are too strict on the manipulator</li> <li>3. Improper acceleration</li> </ol>  | <ol style="list-style-type: none"> <li>1. Confirm whether the manipulator load exceeds the allowable value, and reduce the load or change the action procedures</li> <li>2. Mitigate the specific vibrations by reducing speed, reducing acceleration and changing the action procedures</li> </ol>   |
|                             | <ul style="list-style-type: none"> <li>■ Collision or long-term overload operation of manipulator</li> <li>■ No replacement of lubricating grease for a long time</li> </ul>  | <ol style="list-style-type: none"> <li>1. Mechanical transmission system is subjected to excessive external force due to collision or overload, causing the damage to the gear surface or rolling surface of the gear, bearing, reducer or the peeling due to fatigue</li> <li>2. The gear surfaces or rolling surfaces of gear, bearing and reducer are damaged due to the foreign matters trapped in the gear, bearing or reducer.</li> <li>3. The gear surfaces or rolling surfaces of gear, bearing and reducer peel off due to fatigue because of no replacement of lubricating grease for long term</li> <li>4. The above reasons may cause the periodic vibration or abnormal noise</li> </ol> | <ol style="list-style-type: none"> <li>1. Make the manipulator operate uniaxially to confirm the Joint that produces the vibration and noise</li> <li>2. If you need to replace the gear, bearing and reducer, please contact us.</li> <li>3. Do not use the manipulator at overloaded status</li> <li>4. If you need to replace the lubricating grease, please contact us.</li> <li>5. Please consult with us</li> </ol> |

Table 11-3 Possible Faults and Causes of Manipulator

| Fault                       | Classification   | Possible Causes   | Treatment  |
|-----------------------------|--|---|--|
| Vibration<br>Abnormal noise | Causes may not be determined mechanically  | <ol style="list-style-type: none"> <li>1. Fault of the circuit inside the controller, failure of command to transmit to the motor, or the motor information not correctly transmitted to the controller</li> <li>2. Fault of pulse encoder and the position of motor not correctly transmitted to the controller</li> <li>3. Failure of motor body to perform its original functions</li> <li>4. Breakage of internal motor cable of manipulator causes the command not to be correctly transmitted to the motor and control system</li> <li>5. Voltage drop and no guarantee for the specified voltage</li> <li>6. Incorrect control parameters are input</li> </ol> | <ol style="list-style-type: none"> <li>1. For the fault of controller, see the controller manual</li> <li>2. Replace the motor of vibrating Joint to confirm whether it vibrates</li> <li>3. Check the cables of the manipulator body, between the manipulator body and control cabinet, and inside the controller for damage, and if so, replace the cable.</li> <li>4. Check whether the cable joint is in good contact. In case of the poor contact or looseness, re-tighten or take appropriate measures to ensure the good contact.</li> <li>5. Check whether the action control parameters are correct, and if not, re-enter the correct parameters.</li> <li>6. Please consult with us</li> </ol> |
|                             | The mechanical action near the manipulator is closely related to the vibration of robot. | <ol style="list-style-type: none"> <li>1. Mechanical electrical noise from the manipulator</li> <li>2. If the grounding wire is not connected properly, the electrical noise will mix into the grounding wire, causing the vibration of manipulator due to the interference with command</li> <li>3. Poor connection of grounding wire will lead to the unstable grounding, causing the vibration of manipulator due to electrical noise interference.</li> </ol>   | <ol style="list-style-type: none"> <li>1. Connect the grounding wire properly to avoid the electrical noise mixed into the manipulator</li> <li>2. Please consult with us</li> </ol>   |

Table 11-4 Possible Faults and Causes of Manipulator

| Fault                               | Classification  | Possible Causes  | Treatment   |
|-------------------------------------|---|--|---|
| <p>Vibration<br/>Abnormal noise</p> | <ul style="list-style-type: none"> <li>■ Abnormal noise after the replacement of lubricating grease</li> <li>■ Abnormal noise occurs during the operation of robot after a long-term shutdown</li> <li>■ Abnormal noise at low speed</li> </ul> | <p>1. Abnormal noise from the manipulator at low speed immediately after the replacement or at the restart after the long-term shutdown.</p>                 | <p>1. Observe the operation of manipulator for 1-2 days. Usually the abnormal noise will disappear.</p>   |
| <p>Shake of manipulator</p>         | <ul style="list-style-type: none"> <li>■ After power-off, some parts of manipulator may be shaken manually.</li> <li>■ There is a gap between the connecting surfaces of manipulator</li> </ul>   | <p>1. Manipulator bolts are loose<br/>2. Connecting bolts on the manipulator are loose due to the overload, collision, etc., thus resulting in the shake</p> | <p>For each Joint, check if the bolts at the following parts are loose. If so, tighten it with a torque wrench according to a suitable torque.</p> <ol style="list-style-type: none"> <li>1. Fixing bolts of motor</li> <li>2. Fixing bolts of reducer shell</li> <li>3. Fixing bolts of output shaft of reducer</li> <li>4. Fixing bolts of pedestal</li> <li>5. Fixing bolts between arms</li> <li>6. Fixing bolts of shell</li> <li>7. Fixing bolts of end effector</li> </ol> |
|                                     | <p>Turn off the power of manipulator, and confirm that the screws are tightened, and shake the entire head of manipulator manually</p>  | <p>1. Large backlash is resulted from the wear or damage of internal gears of manipulator due to the overload, collision, etc.</p>                           | <p>1. If you need to replace the internal gear, please consult with us</p>  |

Table 11-5 Possible Faults and Causes of Manipulator

| Fault             | Classification  | Possible Causes  | Treatment  |
|-------------------|---|--|--|
| Motor overheating | <ul style="list-style-type: none"> <li>■ Ambient temperature rise for installation of manipulator, and the overheating of motor</li> <li>■ Motor overheats after the cover plate is mounted on the motor</li> <li>■ Motor overheats after the action procedures of manipulator and load conditions are changed</li> </ul> | <p>Ambient Temperature :</p> <p>1. Ambient temperature rise or the deterioration of heat dissipation of motor after the cover plate is installed</p> <p>Load Action:</p> <p>1. Current value of motor exceeds its rated value due to the load and operating procedures</p>   | <p>1. Decrease of ambient temperature may prevent the motor from overheating</p> <p>2. Improvement of ventilation conditions around the motor, i.e. the heat dissipation of motor, may effectively prevent the motor from overheating.</p> <p>3. A radiation shielding plate if there is a heat source around the motor may prevent the motor from overheating.</p> <p>4. Slowing down the action procedures and reducing the load may decrease the average current value of motor, thus preventing the motor from overheating.</p> <p>5. Please consult with us</p> |
|                   | Motor overheats after the action control parameters of manipulator are changed  | <p>Control Parameter:</p> <p>1. Improper input parameters will cause the incorrect acceleration and deceleration of robot, so that the average current value of increases.</p>   | <p>1. Enter the appropriate parameters according to the relevant instructions.</p> <p>2. Please consult with us</p>  |
|                   | Motor overheats due to the causes other than above ones   | <p>Mechanical Fault of Manipulator:</p> <p>1. Mechanical system fault of manipulator causes the overload of motor</p> <p>Motor fault:</p> <p>1. Brake fault causes the motor to always operate when the brake is applied, which causes the motor to withstand excessive load</p> <p>2. Failure of motor body to perform its functions causes the excessive current to flow through the motor</p> | <p>1. Please rectify the mechanical fault by reference to the instructions of vibration, abnormal noise and looseness.</p> <p>2. Please confirm whether the brake is released when the motor is powered on.</p> <p>3. After the motor is replaced, the overheating of motor disappears. It is confirmed that the this condition is abnormal.</p> <p>4. Please consult with us</p>  |

Table 11-6 Possible Faults and Causes of Manipulator

| Fault                         | Classification   | Possible Causes  | Treatment   |
|-------------------------------|--|--|---|
| Leakage of lubricating grease | Lubricating grease leaks out from the mechanical part  | <p>Poor Sealing:</p> <ol style="list-style-type: none"> <li>1. Crack of casting due to the excessive external force caused by the collision</li> <li>2. Damage of O-ring during the disassembly and reassembly</li> <li>3. Scratch of oil seal due to the dust intrusion</li> <li>4. Poor sealing between the cover plate and casting</li> </ol> | <ol style="list-style-type: none"> <li>1. In case of casting crack, etc., the sealant may be used to block the lubricating grease as an emergency measure, but in view of the further extension of crack, the part shall be replaced as soon as possible.</li> <li>2. Please consult with us</li> </ol> |
| Falling of manipulator axis   | <ul style="list-style-type: none"> <li>■ The brake is completely ineffective and the Joint falls quickly</li> <li>■ After the brake is contracted, the shaft falls slowly</li> </ul> | <ol style="list-style-type: none"> <li>1. The damage of brake drive relay causes the brake to always be powered on and not to work.</li> <li>2. Wear and damage of brake body affect the braking effect.</li> <li>3. The lubricating oil and grease inside the motor cause the brake to slip.</li> </ol>   | <ol style="list-style-type: none"> <li>1. Check if the brake drive relay is damaged, and if so, replace the relay</li> <li>2. In case of the wear of brake, the damage of brake body and the lubricating grease inside the motor, replace the motor.</li> <li>3. Please consult with us</li> </ol>      |

Table 11-7 Possible Faults and Causes of Manipulator

| Fault           | Classification  | Possible Causes   | Treatment   |
|-----------------|---|---|---|
| Position offset | <ul style="list-style-type: none"> <li>■ Manipulator deviates from the teaching position</li> <li>■ The repeated positioning accuracy of manipulator is greater than the allowed value</li> </ul> | <p>Mechanical Fault:</p> <ol style="list-style-type: none"> <li>1. The unstable repeated positioning accuracy may be caused by the mechanical system abnormality, screw looseness, etc.</li> <li>2. The repeated positioning accuracy keeps stable after the deviation; the joint surface of pedestal surface, Joint casting and reducer may slide due to the excessive load such as the collision.</li> <li>3. Abnormality of motor encoder</li> </ol> | <ol style="list-style-type: none"> <li>1. In case of the unstable repeated positioning accuracy, please rectify the mechanical fault by reference to the instructions for the vibration, abnormal noise and shaking.</li> <li>2. If the repeated positioning accuracy keeps stable, please modify the teaching program. If the collision does not occur again, the deviation may be avoided.</li> <li>3. In case of the abnormality of motor encoder, replace the motor or encoder.</li> <li>4. Please consult with us</li> </ol> |

| Fault | Classification  | Possible Causes  | Treatment  |
|-------|---|--|--|
|       | Position only deviates from the specific peripheral equipment | Deviation of Peripheral Equipment<br>1. The external equipment under the external force leads to the deviation relative to the manipulator | 1. Please relocate the peripheral equipment<br>2. Please modify the teaching program<br>3. Please consult with us  |
|       | Deviation occurs after the modification of parameters         | Parameters:<br>1. The modification of calibration data causes the loss of manipulator origin   | 1. Re-enter the previous correct calibration data<br>2. In case of uncertain calibration data, please recalibrate the manipulator<br>3. Please consult with us |





## Appendix A AIR4-560A type manipulator regular maintenance table

Appendix A Periodic Maintenance Schedule of AIR4-560A Manipulator

| Item | Mainten<br>ance cycle   | First<br>Maintenance<br>320h | 3<br>months<br>960h   | 6<br>months<br>1,920h | 9<br>months<br>2,880h | 1 year<br>3,840h      | 15<br>months<br>4,800h | 18<br>months<br>5,760h | 21<br>months<br>6,720h | 2<br>years<br>7,680h  | 27<br>months<br>8,640h | 30<br>months<br>9,600h | 33<br>months<br>10,560h | 3 years<br>11,520h    | 39<br>months<br>12,480h | 42<br>months<br>13,440h | 45<br>months<br>14,400h | 4 years<br>15,360h    | 51<br>months<br>16,320h | 54<br>months<br>17,280h | 57<br>months<br>18,240h | 5 years<br>19,200h    |
|------|---|------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|------------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|-------------------------|-----------------------|-------------------------|-------------------------|-------------------------|-----------------------|-------------------------|-------------------------|-------------------------|-----------------------|
| 1    | Cleaning of manipulator   | 0.5h                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> |
| 2    | Cleaning of control cabinet vent  | 0.1h                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> |
| 3    | Wether the synchronous belt worn  | 0.5h                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> |
| 4    | Check the manipulator cable for damage  | 3h                           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> |
| 5    | Check the manipulator cable sheath for damage   | 2h                           | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> |
| 6    | Check the connecting cable of teach pendant, control cabinet and manipulator for damage | 0.2h                         | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/>  | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/>   | <input type="radio"/> |

| Item | Mainten<br>ance cycle                                     | First<br>Maintenance<br>320h | 3<br>months<br>960h | 6<br>months<br>1,920h | 9<br>months<br>2,880h | 1 year<br>3,840h | 15<br>months<br>4,800h | 18<br>months<br>5,760h | 21<br>months<br>6,720h | 2 years<br>7,680h | 27<br>months<br>8,640h | 30<br>months<br>9,600h | 33<br>months<br>10,560h | 3 years<br>11,520h | 39<br>months<br>12,480h | 42<br>months<br>13,440h | 45<br>months<br>14,400h | 4 years<br>15,360h | 51<br>months<br>16,320h | 54<br>months<br>17,280h | 57<br>months<br>18,240h | 5 years<br>19,200h |
|------|---|------------------------------|---------------------|-----------------------|-----------------------|------------------|------------------------|------------------------|------------------------|-------------------|------------------------|------------------------|-------------------------|--------------------|-------------------------|-------------------------|-------------------------|--------------------|-------------------------|-------------------------|-------------------------|--------------------|
| 7    | Check the connectors of motor, etc. for looseness<br>0.2h | ○                            |                     |                       |                       | ○                |                        |                        |                        | ○                 |                        |                        |                         | ○                  |                         |                         |                         | ○                  |                         |                         |                         | ○                  |
| 8    | Tighten the end effector screws<br>0.2h                   | ○                            |                     |                       |                       | ○                |                        |                        |                        | ○                 |                        |                        |                         | ○                  |                         |                         |                         | ○                  |                         |                         |                         | ○                  |
| 9    | Tighten the external main screws<br>1h                    | ○                            |                     |                       |                       | ○                |                        |                        |                        | ○                 |                        |                        |                         | ○                  |                         |                         |                         | ○                  |                         |                         |                         | ○                  |
| 10   | Check the end effector cable for damage<br>0.2h           | ○                            |                     |                       |                       | ○                |                        |                        |                        | ○                 |                        |                        |                         | ○                  |                         |                         |                         | ○                  |                         |                         |                         | ○                  |
| 11   | Check the limit rubber block for damage<br>0.1h           | ○                            |                     |                       |                       | ○                |                        |                        |                        | ○                 |                        |                        |                         | ○                  |                         |                         |                         | ○                  |                         |                         |                         | ○                  |
| 12   | Replacement of Synchronous Belt<br>1h                     |                              |                     |                       |                       | ○                |                        |                        |                        | ○                 |                        |                        |                         | ○                  |                         |                         |                         | ○                  |                         |                         |                         | ○                  |
| 13   | Battery Replacement<br>0.5h                               |                              |                     |                       |                       |                  |                        |                        |                        | ○                 |                        |                        |                         |                    |                         |                         |                         | ○                  |                         |                         |                         |                    |
| 14   | Replace the internal cables of manipulator<br>8h          |                              |                     |                       |                       |                  |                        |                        |                        |                   |                        |                        |                         |                    |                         |                         |                         | ○                  |                         |                         |                         |                    |
| 15   | Manipulator overhaul                                      |                              |                     |                       |                       |                  |                        |                        |                        |                   |                        |                        |                         |                    |                         |                         |                         |                    |                         |                         |                         | ○                  |

| Item | Maintenance cycle | First Maintenance<br>320h | 3 months<br>960h | 6 months<br>1,920h | 9 months<br>2,880h | 1 year<br>3,840h | 15 months<br>4,800h | 18 months<br>5,760h | 21 months<br>6,720h | 2 years<br>7,680h | 27 months<br>8,640h | 30 months<br>9,600h | 33 months<br>10,560h | 3 years<br>11,520h | 39 months<br>12,480h | 42 months<br>13,440h | 45 months<br>14,400h | 4 years<br>15,360h | 51 months<br>16,320h | 54 months<br>17,280h | 57 months<br>18,240h | 5 years<br>19,200h |
|------|-------------------|---------------------------|------------------|--------------------|--------------------|------------------|---------------------|---------------------|---------------------|-------------------|---------------------|---------------------|----------------------|--------------------|----------------------|----------------------|----------------------|--------------------|----------------------|----------------------|----------------------|--------------------|
|------|-------------------|---------------------------|------------------|--------------------|--------------------|------------------|---------------------|---------------------|---------------------|-------------------|---------------------|---------------------|----------------------|--------------------|----------------------|----------------------|----------------------|--------------------|----------------------|----------------------|----------------------|--------------------|

Note: ○ indicates that maintenance is required



## Appendix B Table of screw strength and tightening torque (Nm)

Appendix B Table of screw strength and tightening torque (Nm)

| Thread specification | Performance level |            |            |
|----------------------|-------------------|------------|------------|
|                      | 8.8 level         | 10.9 level | 12.9 level |
| M2                   | 0.35              | 0.48       | 0.56       |
| M2.5                 | 0.68              | 0.93       | 1.1        |
| M3                   | 1.2               | 1.6        | 2          |
| M4                   | 2.8               | 3.7        | 4.4        |
| M5                   | 5.6               | 7.5        | 9          |
| M6                   | 9.5               | 12.5       | 15         |
| M8                   | 23                | 31         | 36         |
| M10                  | 45                | 60         | 70         |
| M12                  | 78                | 104        | 125        |
| M14                  | 113               | 165        | 195        |
| M16                  | 195               | 250        | 305        |
| M20                  | 370               | 500        | 600        |



Prompt

- All screws must be tightened with proper torque.
- Except for the torque specified in the text, the corresponding tightening torque shall be selected according to the screw performance level.
- Remove foreign matters in screws and threaded holes.
- Torque for lightly lubricated screws.
- Screws shall be tightened evenly and symmetrically.
- According to the installation requirements of the reducer and other moving parts, apply thread adhesive to the engagement part of some screws.





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