Safety Manual for Collaborative Robot

Safety Manual

V1.0

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The original language of this Publication is Chinese.

International standard units are adopted in all publications. GB means Chinese national standard.

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1 Safety instructions

Please thoroughly read and understand the contents in this Manual before operating the collaborative robots produced by Agilebot Robotics Co., Ltd. (hereinafter referred to as Agilebot).

In this Manual, the robot system refers to an integrated system composing the body, controller, wired handle, cables, software and other accessories of the collaborative robot. When designing the robot system, the integrator must fully consider safety precautions for the user and the system and observe the safety requirements of the standards and regulations of relevant countries.

Nobody is allowed to modify the collaborative robot without authorization from Agilebot Robotics Co., Ltd. Agilebot Robotics Co., Ltd. shall assume no responsibility for any damage to the collaborative robot or its components due to the use of any other components (software, tools, etc.) not provided by Agilebot.

Besides safety precautions in this chapter, it is also required to observe other safety instructions specified in this Manual.

Caution

Applicable models in this Manual:

- GBT-C5A Series Collaborative Robots

1.1 Definition of safety signs

This Manual includes safety signs for protecting the personal safety of users and avoiding any damage to the machine and describes them with "Danger" and "Warning" in the main text based on their importance in safety.

In addition, relevant supplementary explanations are described as "Caution".

Before use, the user must thoroughly read the precautions described in "Danger", "Warning" and "Caution".

Identification	Definition
Danger	It indicates dangerous situations possibly resulting in serious injury or death to the user during incorrect operation.
Warning	It indicates dangerous situations possibly resulting in mild or moderate personal injury or property damage during incorrect operation.
Caution	It provides supplementary explanations outside the scope of danger or warning.

Please read this Manual carefully and keep it secure for easy reference at any time.

1.2 Definition of user

The operators are defined as follows:

➢ Operator

Perform power-on/off operation on the robot.

Start the robot program from the panel board.

➢ Robot Engineer

Operate the robot.

Perform teaching and programming debugging of the robot.

➢ Maintenance Engineer

Operate the robot.

Perform teaching of the robot.

Carry out maintenance (repair, adjustment, replacement) operations on the robot.

The user must receive professional training on the robot. When operating, programming and maintaining the robot, the operator, programmer and maintenance engineer must clearly give a safety warning and wear at least the following protective articles.

- ➢ Work clothes suitable for operations
- ➢ Safety shoes
- ➢ Safety helmets
- ➢ Goggles

⚠ Warning

1. Ensure that robot arms and tools (or end-effector) are correctly and firmly bolted.
2. Ensure that the robot arms have sufficient spaces of free movement.
3. Ensure that safety measures and parameters have been established to protect the users based on risk assessment.
4. Never wear loose clothes or jewelry when operating the robots. Tie long hair (if any) behind your head when operating the robot.
5. Always keep your head and face outside the reach of the robot during operation.
6. Never enter the safe range of the robot or touch the operating robot if a safe range has been determined by risk assessment.
7. The user must be aware of the position of the E-stop button.

1.3 Robot training

The operator, robot engineer and maintenance engineer must receive the following operation and maintenance training.

- ➢ Fundamentals of robots

- Safety precautions for robots
- Jogging of robots
- Manual operation and teaching of robots
- Program creation, teaching and operation
- Auto run
- Composition and functionality of a robot
- Setting of coordinate system
- System backup and recovery
- Zero calibration
- Robot mounting method

We have robot training courses available. Please contact us for details.

 Warning

The operator, robot engineer and maintenance engineer should receive training in accordance with the laws of the countries or regions where robots are mounted and operated. Those working inside the working range of the robot without training may be caught or collided by the robot body, posing the risk of serious injury or death.

2 About Agilebot robots

2.1 Operating situations of robots

GBT-C5A series collaborative robots can be used to operate tools, end-effectors or fixtures, or process and transport workpieces. Meanwhile, it has a safety function designed for human-machine cooperation. If confirmed through safety assessment, it can work without safety fence.

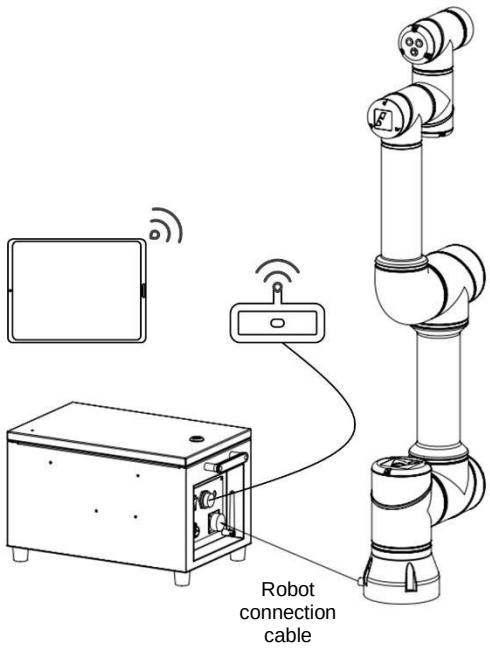
Agilebot assumes no responsibility for any consequences caused by misuse of the collaborative robot. Any use or application against the design purposes is not allowed. This includes but is not limited to the following:

- Use the robot beyond the designed parameter range
- Use it as a carrier for humans or animals
- Use it as a climbing tool
- Use it in explosive environments
- Use it for medical and life-related applications

Warning

1. Only use the industrial robot for the purposes specified in the Manual.
2. This product is not suitable for hazardous locations or explosive environments.
3. This product is not suitable for medical applications coming into contact or close to the human body.
4. Any use or application deviating from the design purpose, specifications and certification may result in death, personal injury and/or property damage.

2.2 Overview of robot components



Wireless or wired connection can be adopted between the robot and the operating terminal. During usage, the following components should be included:

Operating terminal *: A device used by the users for programming, setting and other operations.

Robot body: A major moving component used for achieving the desired actions of the user. A circular light is arranged on the end cap of each joint to display the status of the robot. Meanwhile, there are shortcut buttons and IO interfaces of connecting tools on the end.

Controller and its handle: The controller includes key computing components and various electrical interfaces. Meanwhile, the electric controller is equipped with a handle convenient for users to operate it.

Routers and network cables **: The controller is equipped with wireless modules and the operating terminal can be connected to the wireless LAN (wireless network name is robot model + MAC address) of the controller to operate and control the robot. The controller can also be connected to the router with cables and the operating terminal can be connected to this router through wireless or wired means. It is recommended to provide the robot with an independent router (if used) to prevent any conflict with other devices.

* The operating terminal should be purchased separately and is not included in the shipping package of the robot.

** Please purchase additional routers and network cables (if required).

2.3 Safety warning label

Both the robot and the controller bear several safety and information labels, which contain important information related to the product. This information is very useful for all persons operating the robot system, e.g. during mounting, maintenance or operation.

The safety labels are only graphical and applicable to all languages.

Caution

It is required to observe the safety and health signs on the product label. In addition, it is also necessary to comply with the supplementary safety information provided by the system builder or integrator.

Sign	Description
	Warning - electric shock
	Warning - hands pinching
	Beware of burns due to high temperature.
	Grounding

2.4 Risk assessment

2.4.1 Risk

Any interactive relationship between the operator and the robot may necessarily involve direct or indirect physical contact. The user must have sufficient self-protection awareness when in contact and should carefully consider operating conditions when operating the Agilebot collaborative robot. The following are potential hazardous situations:

- The robot may fall down and cause personal injury during handling.
- The robot may cause finger pinching and collision injuries during operation.
- Loose fixing screws of the robot may cause injuries.
- The robot may cause injuries when operating in toxic, harmful or corrosive environments.
- The robot malfunctioning and not being timely repaired may cause injuries.

- A sharp end-effector or connecting terminal (if used) may pose hazards.

2.4.2 Risk assessment

Any collaborative robot system is designed with protective measures to ensure the safety of the operator during collaborative operations at all times. So, risk assessment is necessary. It is required to perform corresponding hazard identification and risk assessment in the application of collaborative robot systems, so that relevant measures can be adopted to reduce the risks.

Many countries and regions have issued relevant legal requirements. The robot is a semi-finished device. So, the mounting safety of the robot depends on its integration method (such as tools/end-effector, obstacles and other machines. It is recommended to adopt ISO 12100 and ISO 10218-2 for risk assessment. In addition, ISO/TS 15066 can be chosen as a supplement.

All work tasks of the robot system should be considered during risk assessment, including but not limited to:

- Teaching the robot during the mounting and debugging
- Fault diagnosis and maintenance
- Normal operation of the robot

Risk assessment must be performed before the robot is first turned on. Based on the conclusions of risk assessment, measures can be taken to reduce risks, e.g. limiting the movement of the robot or appropriately configuring safety functions.

In risk assessment, special attention should be paid to:

- Correct security configuration
- Reasonable TCP motion speed or joint motion angle
- Small amplitude of TCP jittering during robot de-excitation or excitation
- Stopping time and distance of the robot (related to the layout of the workspace for the operator and obstacles)
- Hazards caused by workpieces, end-effector, peripherals, or application devices
- Whether to configure additional E-stop buttons or protective equipment required for specific robot applications.

Application risk assessment must be performed for human-machine collaboration or contact during process actions, and the following issues must be taken into consideration:

- Severity of individual potential collision
- Possibility of individual potential collision
- Possibility of avoiding individual potential collision

If the built-in safety features of the robot have been fully utilized and the risk is still reduced to an acceptable level, additional protective measures must be added, e.g. adding safety fence, safety grating and other devices.

2.4.3 Assessment before use

After the robot is used for the first time or the configuration is modified, the following tests must be conducted to confirm that all safety inputs and outputs are normal and all connections are correct:

- Test whether the E-stop button and external E-stop input can stop the robot.
- Test whether RESET or externally-input RESET signal can correctly clear errors and excite the robot.
- Test the scale-down mode signal to verify if it is possible to switch between normal and scale-down modes.
- Test whether the operation mode selector can switch operation modes (the operation mode may be displayed in the upper right corner of the user interface of the operating terminal).
- Test whether the enabled safety output signal can be output normally.
- Test whether the E-stop output of the system can actually switch the entire system to a safe status.

3 Safety-related functions

3.1 Methods for stopping the robot

The methods for stopping Agilebot collaborative robots include:

Class 0 stop

- Immediately cut off the power supply of the robot to achieve a stop, namely, uncontrolled stop.

Class 1 stop

- Gradually stop the machine/equipment while maintaining the power supply to the actuator of the machine/equipment. Cut off the power supply only when the machine/equipment is completely stopped. This is a controlled stop.

Class 2 stop

- This is a controlled stop. After the robot stops, the power supply to the driving device of the machine/equipment remains constant.

3.2 E-stop

The Agilebot collaborative robot is provided with the following E-stop devices:

- E-stop button with a wired handle
- External E-stop device (input signal)

It is required to activate the E-stop device in case of danger or emergency.

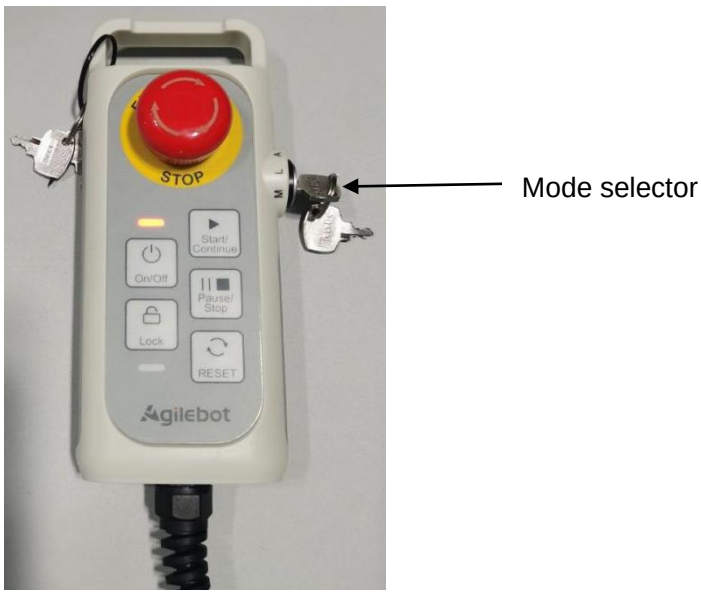
The robot immediately executes the Class 1 stop when the E-stop device is pressed. First rotate the E-stop device for unlocking and then turn on the servo power to continue the operation.

The input signal of external E-stop is a signal input by peripheral devices and the terminal of this signal is located inside the controller. Please refer to the Manual of each controller for the actual position of the E-stop button.

3.3 Operation mode selector

It is allowed to choose the operation mode of the robot by inserting the key and rotating the gear. In addition, it is possible to prevent others from changing the operation mode by removing the key.

When the operation modes of the robot are switched by the operation mode selector, the robot can definitely stop and a message is displayed on the operating terminal, informing that the operation mode has been switched.



3.3.1 Operation mode

Manual maximum-speed mode (M)

This is a mode for robot program debuggers or operators to debug the motions of the robot. In this mode, it is allowed to mainly perform the following operations:

- Teach the robot.
- Enter the manual guidance mode.
- Debug executive programs, including positive-sequence continuous executive programs, positive-sequence single-step executive programs, and reverse-sequence single-step executive programs.
- Edit and modify robot programs.

In this mode, the following operations are prohibited.

- Start and execute robot programs through external signals.

Manual limited-speed mode (L)

This is a manual mode where the robot has a limited speed, and its purpose is the same as the manual mode. However, it is only required to adjust and maintain the robot's motion speed below 250mm/s or 18.5 °/s to prevent accidents caused by excessive speed during manual operation.

In this mode, it is allowed to mainly perform the following operations:

- Teach the robot.
- Enter the manual guidance mode

- Debug executive programs, including positive-sequence continuous executive programs, positive-sequence single-step executive programs, and reverse-sequence single-step executive programs.
- Edit and modify robot programs.

In this mode, the user is mainly prohibited from performing the following operations:

- Start and execute robot programs through external signals.

In this mode, the following restrictions are posed on the motion speed of the robot during program debugging or execution:

- The motion speed of the Cartesian motion command is always below 250mm/s.
- The motion speed of the joint motion command is always below 18.5°/s.
- The speed is limited based on the teaching speed at 100% magnification. Therefore, at a teaching speed of 2000mm/s, the speed is limited to 250mm/s if the magnification is 100% and to 125mm/s if the magnification is 50%. Thus, the speed can be further slowed down by lowering the magnification.

Auto mode (A)

This is the mode for automatic operation of the robot during normal operation. In this mode, the robot obtains the program information or program number to be executed through communication or IO and then executes it.

In this mode, it is allowed to mainly perform the following operations:

- Execute the robot program through the startup method selected in the "Program Startup Mode".

In this mode, the user is mainly prohibited from performing the following operations.

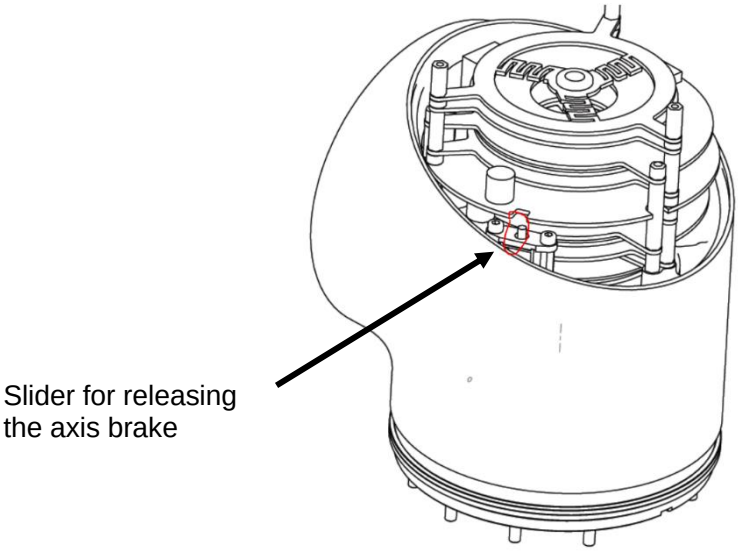
- Teach the robot.
- Enter the manual guidance mode.
- Debug executive programs, including positive-sequence single-step executive programs and reverse-sequence single-step executive programs.
- Edit and modify robot programs.
- Modify relevant configurations of the robot.

3.4 Motion without electric drive

In such emergency situations as power failure or no power, two different methods can be adopted to forcibly move the robot joints:

1. Forcible manual drive: force the joints to rotate by pushing or pulling the robot arm. The brake of each joint is provided with a friction clutch. The joint can rotate when the torque borne by the joint is higher than the safe torque of the friction clutch.

2. Manual release of the brake: Dismantle several screws fixing the joint end cover and then remove the end cover. Press the slider in the small electromagnet (as shown in the figure below) to manually release the brake.



Warning

1. The forcible manual drive of the robot arm is only allowed in emergency situations and may damage the joint. So, it cannot be used as daily operation.
2. The robot may move under the action of gravity if the brake is manually released. Therefore, before the brake is manually released, it is necessary to effectively support the robot body and the tools or workpieces mounted on the robot.

4 General precautions

This chapter explains safety requirements for the following conditions.

- Precautions in transportation and handling
- Mounting
- System composition and functional test
- Precautions for robot body
- Resolution of common faults
- Safety of maintenance engineers
- Maintenance
- Dismantling and scrapping

In order to ensure the safety of personnel other than operators using teach pendant or enabling device in connection with robot operations, the user must prepare, use and maintain safety protection measures. The user must avoid wrongly using the teach pendant not connected to the robot controller.

Caution

Immediately after motion, the motor, braking resistor and power transformer of the robot may become hot. Take care not to contact these components as much as possible. If it is necessary to contact these components for maintenance purposes, please be aware of burns due to high temperature.

Warning

Especially during teaching or maintenance, unrelated personnel must not enter the working range of the robot. Otherwise, there is a risk of being pinched by the robot or causing serious injury or death.

4.1 Precautions in transportation and handling

During transportation, it is necessary to fix the original package and ensure that the robot is stable and dry.

When the robot is lifted, corresponding measures should be taken for positioning to avoid accidental movement or damage.

Support the robot until all bolts on the base are firmly fastened when the robot is moved from its package to the mounting position.

Warning

1. Ensure that the operator's back or other parts do not bear excessive weight when lifting the device. Use an appropriate lifter. Agilebot assumes no responsibility for any damage occurred during the transportation.

2. Strictly observe the mounting instructions when mounting the robot.

4.2 System composition and functional test

Develop testing steps for the robot or the robot system after mounting or location changes. Please implement this step as well after changes to the robot or robot system (e.g. hardware or software changes, component replacement, adjustment, etc.) or after maintenance and repair possibly affecting safe operation.

4.2.1 Proper configuration of robot's operating space

The working ranges must be confirmed for all robots or robot systems before use. If it is confirmed that additional protective devices are required after careful risk assessment and the planned safety protection devices are not in place before test run and functional test, temporary measures (e.g. installing chains, lightweight wall panels, warning fences, etc.) should be taken to limit the mounting space before operation.

4.2.2 Entry restrictions for users

During system construction and functional testing, the users are not allowed to enter the safety protection area until the safety protection devices are available.

4.2.3 Confirmation of safety and operation

The composition and testing of the robot or robot system should be carried out according to the manufacturer's instructions. At least the following items should be included in the initial startup steps.

- Before powering on, the following issues should be checked and confirmed.
  - The robot has been mounted correctly according to the instructions and has good stability.
  - Electrical connection has been made correctly and the power parameters (such as voltage, frequency, interference level, etc.) are within the specified range.
  - Other facilities (such as water, air, gas, etc.) are connected correctly and within the specified limits.
  - Communication connection is made correctly.
  - Peripheral devices and the system are connected correctly. A limit device has been mounted to restrict the space.
  - Safety measures have been taken.
  - The surrounding environment complies with relevant regulations (such as lighting, noise level, humidity, temperature, atmospheric pollution, etc.).
- After powering on, the following issues should be checked and confirmed.
  - The functions of the robot system controller, such as start, stop and operation modes (including keyed locking switch), meet the predetermined requirements and the robot can move according to the predetermined commands of the operating system.
  - All axes of the robot can move within the expected limited ranges.
  - Emergency stop and safety stop circuits and devices are effective.
  - It can be disconnected and isolated from external power sources.
  - The wired handle is functioning normally.
  - The safety protection devices and interlocks are functioning normally and other safety protection devices (e.g. fences and warning devices) are in place.
  - At "slow speeds", the robot can operate normally and is able to accomplish tasks.
  - Under the automatic (normal) operation mode, the robot operates normally and is able to complete predetermined tasks at a rated load and required speed.

4.2.4 Steps for restarting the robot system

After replacing, repairing or maintaining the software, hardware and task programs, the following steps should be followed when restarting the robot and its system:

- Before powering on, check any changes or additions to the hardware.
- Perform the functional test to check whether the robot system is operating correctly.

4.3 Precautions for robot body

1. The robot should be operated in the environment specified in the Manual.
2. Never use cutting fluids and cleaning agents with unknown properties.
3. Limit the movement of the robot to avoid collisions among the robot, cables, peripheral devices and tools.
4. The following precautions should be observed for the cables inside the robot. Unexpected malfunctions may occur if the following precautions are not followed.
    - The cables inside the robot should be equipped with necessary user interfaces.
    - Never add cables and hoses inside the robot.
    - When mounting tubes outside the robot, take care to avoid obstructing the movement of the robot.
    - When mounting external devices on the robot, it should be noted to avoid interference with other parts of the robot and meet the payload requirements of this model (in accordance with the load curve diagram).
5. For the robot in motion, frequent power-off and stop operations, e.g. by pressing the E-stop button, may lead to robot malfunctions. It is required to avoid system designs causing power-off and shutdown in daily conditions.

Conditions to be avoided:

- Every time a defect occurs, the system can power off and stop the operating robot by the emergency stop.
- When adjusting the robot body or tools, open the door of the safety fence to activate the safety door signal, causing the running robot to power off and stop.
- Frequently press the emergency stop button to stop the production line.
- The area sensor and foot pad alarm switch connected to the E-stop signal are also frequently activated in normal times, causing the robot to power off and stop frequently.

6. In case of a collision detection alarm or other alarm, the robot may also be powered off and stopped. Frequent emergency stops due to alarms may cause malfunctions in the robot. It is required to rule out the cause of the alarms.

4.4 Resolution of common faults

Please handle common faults outside the safety protection area. Make sure to follow the following precautions if it is necessary to handle common faults within the safety protection area due to the situation of the robot system.

- The operator responsible for handling common faults must hold the qualifications for the task and have received specialized training.
- The operator entering the safety protection area should be provided with additional safety devices as needed.
- Please establish the safe operation steps in advance to minimize the possibility of danger for the users within the safety protection area.

4.5 Safety of maintenance engineers

Fully observe the following precautions to ensure the safety of the maintenance engineer.

1. Never enter the range of motion of the robot during its operation.
2. Try to complete the operation with the robot and system power disconnected as much as possible. When the power is turned on, some tasks may cause a risk of electric shock. In addition, lockout should be performed as needed to prevent others from turning on the power supply. Even if it is necessary to turn on the power before any operation, it is advisable to press the emergency stop button as much as possible in advance.
3. When it is necessary to enter the range of motion of the robot due to unavoidable circumstances in the power-on state, the emergency stop button on the operation box/panel or teach pendant should be pressed in advance. In addition, the user should provide a tag indicating "maintenance in progress" to remind others not to operate the robot arbitrarily (LOTO).
4. When repairing the pneumatic system, make sure to release the air pressure and reduce the pressure in the pipeline to 0 in advance.
5. Before maintenance, it should be confirmed that the robot or peripheral devices are not in a dangerous state and free of any abnormalities.
6. It is noted not to block the escape routes of other users when operations are performed near walls and appliances or several users are close to each other.
7. When tools are provided on the robot and there are conveyor belts and other movable devices in addition to the robot, it is required to fully note the movement of these devices.
8. During operation, a person familiar with the robot system and able to detect danger should be assigned next to the operation box/panel, so that he/she can press the emergency stop button at any time.
9. Please consult us when replacing components. The replacement under the sole judgment of the customer may lead to unexpected accidents, resulting in damage to the robot or injury to personnel.
10. During component replacement or reassembling, it is required to avoid the adhesion or mixing of foreign objects.
11. If it is necessary to touch the unit, printed circuit board, etc. during the repair inside the controller, it is required to firstly disconnect the power supply of the controller in advance in order to prevent electric shock.
12. The replacement parts must be those specified by us. The use of other parts may lead to incorrect operation and damage.
13. When restarting the robot system after maintenance, it is required to note whether there are people within the action range and whether there are any abnormalities in the robot and peripheral devices.
14. When disassembling the motor and the brake, a crane should be used for lifting before dismantling to prevent arms from falling off.
15. Take care for slipping due to the lubricating oil on the ground. Wipe off any lubricating oil on the ground as soon as possible to avoid danger.
16. Please note that the following parts may be hot. Heat-resistant gloves and other protective devices should be available when it is necessary to touch the equipment in a hot state.

- Interior of controller
- Robot joints

17. Appropriate lighting fixtures should be provided during maintenance. However, it should be noted that this lighting fixture must not become a new source of danger.
18. When heavy components and units, such as motor and gearbox, are used, cranes or other auxiliary devices should be used to avoid excessive workload for users. It should be noted that misoperation may cause serious injury to the user.
19. During the operation, do not put your feet on any part of the robot or climb onto it. Otherwise, it may not only cause adverse effects on the robot, but also lead to injuries due to misstep.
20. During working at height, please ensure secure scaffolding and fasten the safety belt.
21. After maintenance, thoroughly clean oil, water, debris, etc. scattered on the ground around the robot.
22. The components (bolts, etc.) removed during replacement should be correctly reinstalled to original positions. If it is found that the components are insufficient or excessive, they should be confirmed again and installed correctly.
23. It is essential to carry out regular maintenance. Neglecting regular maintenance may not only affect the functionality and lifespan of the robot, but also lead to unexpected accidents.

4.6 Maintenance

In order to ensure safe operation, please prepare a manual of inspection and maintenance points for the robot or robot system. The manual of inspection and maintenance points should consider the recommendations of the robot or robot system manufacturer.

The maintenance engineer should receive sufficient training on necessary steps for safe operation.

The maintenance engineer should take safety precautions against hazards. If possible, please place the robot in a predetermined position and repair it outside the safety protection area.

Please perform maintenance on the robot system when the power supply to the robot system is cut off. During maintenance under the power-on state, it is possible to come into contact with high voltage parts, causing electric shock.

4.7 Dismantling and scrapping

Please contact us when dismantling or scrapping the Agilebot robot.

When dismantling or scrapping robots, make sure to follow the methods specified by us. Otherwise, the robot may overturn wholly or partly due to loss of balance, resulting in accidents of injury or death to the operators.

Caution

Properly dispose the batteries used for storage backups on the robot. When discarded, battery breakage or fire may occur if the battery terminals are short-circuited.

5 Routine maintenance

5.1 Robot body

Carry out inspections and maintenance according to the instructions in the manual to ensure the safety of the robot system. In addition, clean all parts of the system and visually check for any damage. The following are routine inspection items (not necessarily limited to these).

- Assembly of the robot and peripheral devices
- Power supply voltage
- Effectiveness of safety switch on wired handle
- Damage to connecting cable
- Lubricating state
- Emergency stop function
- Vibration and noise of robot actions
- Functions of peripheral devices
- Looseness of connectors
- Air pressure

5.2 Controller

In addition, clean all parts of the system and visually check for any damage to the system before daily operation. In addition, please confirm the following issues.

- Before maintenance operation

1. Check if the controller and peripheral devices are abnormal.
2. Check if the cable connected to the wired handle is excessively distorted.
3. Check if the safety function is normal.

- After maintenance operation

1. Return the robot to the appropriate position and cut off the power supply to the controller.
2. Clean dust (if any) on the ventilation openings and fan motors of the controller.
3. Clean all areas and check for any damage.

Contact us

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