Safety Manual

Safety Manual

V1.0

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1. Safety instructions

It is necessary to read and understand the contents described in this chapter before using industrial robots. This Manual is not fully applicable to collaborative robots.

In this Manual, the robot system refers to an integrated system integrating the industrial robot and its controller, teach pendant, cables, software and other accessories. So, it is required to fully consider the safety precautions of the user and the system.

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

Agilebot Robotics Co., Ltd. assumes no responsibility for any consequences caused by misuse of the industrial robot. The misuse includes:

- Use the robot beyond the specified parameter range
- Use it as a carrier for humans or animals
- Use it as a climbing tool
- Use it in explosive environments
- Use it without safety protection

Besides safety precautions in this chapter, this Manual contains other safety instructions, which must be followed as well.

Caution

Applicable models in this Manual are as follows.

·PUMA series

·SCARA series

1.1 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 within the safety fence.

- Maintenance Engineer

Operate the robot.

Perform teaching of the robot within the safety fence.

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

The “Operator” is not allowed to enter the safety fence.

The "Robot Engineer" and "Maintenance Engineer" can carry out operations within the safety fence.

The operations within the safety fence include (but are not limited to) handling, setting, teaching, adjustment, maintenance, etc.

To carry out the operations within the safety fence, it is necessary to receive professional training on the robot.

When operating, programming and maintaining the robot, the operator, robot engineer and maintenance engineer must take care and wear at least the following protective articles.

- Working clothes
- Safety shoes
- Safety helmets
- Goggles

2. Agilebot robot system

2.1 Operating situations of robots

Do not operate Agilebot robots in the following situations (environments). Otherwise, it may pose a safety hazard to the Agilebot robot and peripheral devices and also cause serious injuries to the user.

- Explosive environment
- Flammable environment
- Water or high humidity environment
- High-radiation environment
- Use the robot as a climbing tool (climb onto the robot or hang under it).
- Use the robot to carry living organisms.
- Outdoor
- Use the robot in the mounting or operating condition not recommended by us.

Agilebot robots are applicable to the following process conditions.

- Polishing
- Handling
- Deburring
- Visual inspection/positioning
- Assembly, etc.

Please confirm with us if you want to use Agilebot robots in process conditions other than those mentioned above.

Agilebot shall bear no responsibility for any malfunctions or accidents caused by incorrect use. Before use, first confirm the specifications of the robot and all applicable standards and fully implement appropriate safety measures in response to existing hazards.

2.2 Composition of robot system

The robot system is composed of the following components.

- Robot body
- Controller
- Teach pendant
- End-effector
- Workpiece
- Safety device
- Safety gate

- Safety fence
- Other peripheral equipment (devices)

Except for the robot body, controller and teach pendant of the robot, other components depend on actual applications and should be prepared by the customer. The controller of the Agilebot robot is provided with an interface for connecting the safety device. Please confirm its sizes and then design the safety system.

We have confirmed the safety of the following components.

- Robot body
- Controller and teach pendant

The customer is required to prepare the following components in the robot system.

- Safety device
- Safety gate
- Safety fence

Since there are multiple schemes for designing end-effector, other peripheral machines, workpieces, etc., Agilebot cannot guarantee the safety of these schemes. In order to ensure the safety of the robot system design, the designer should carry out a design satisfactory to the safety standards in accordance with the *Robots for Industrial Environments - Safety Requirements - Part 1: Robot* (GB 11291.1-2011**[NOTE]**).

[NOTE]

GB 11291.1-2011 Correspondence standard: ISO 10218-1:2006, ISO 10218-1/Cor.1:2007 Robots for industrial environments–Safety requirements–Part 1:Robot

2.2.1 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 safety fence without training may be caught by the robot body, causing serious injury or death.

3. Design of robot system

The design requirements for robot system are explained from the following aspects in the following.

- Safeguarded space
- Safety protection and design of robots
- Connection of power supply and protective grounding
- Design of end-effector, workpiece and peripheral devices
- Other precautions

In addition, basic requirements for end-effector, workpieces and peripheral devices are outlined in Section 3.5.

For safety fence, safety gate and other protective devices, please refer to Sections 4.5-4.7.

3.1 Summary

When the robot system is designed and constructed, it is necessary to consider potential failures of each component, such as electrical system, mechanical system, air compression system or hydraulic system, to ensure that the safety functions are not affected.

The design should be ergonomic to minimize employees' discomfort, physical fatigue and other expected conditions under mental stress. For example:

- Consider the differences in body sizes, strength and endurance of the user.
- Provide a sufficient operating space.
- Avoid continuous operations with high concentration and focus.
- Use different human-machine interfaces.

The electrical system devices in the robot system should comply with GB/T5226.1-2019**[NOTE]**

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[NOTE]

GB/T 5226.1-2019 Correspondence standard: IEC 60204-1:2016,Safety of machinery–Electrical equipment of machines–Part 1:General requirements

3.2 Safeguarded space

The safeguarded space is a space composed of safety devices (e.g. fences) around the robot. The size of the safeguarded space is determined through risk assessment. It is the additional space required beyond the reach of the robot. Generally, it should be considered that all body parts cannot come into contact with the moving parts of the robot and the working range of the end-effector or workpiece during the operation of the robot.

3.3 Safety protection and design of robot system

All elements of the robot system should meet the following requirements.

- Design safety/protective fence, safety gate and protective devices according to safety standards. For the requirements for safety protection methods and protective devices, please

refer to Sections 4.6 and 4.7.

- When designing the protection range, it is required to conduct a risk assessment and set a blank area outside the restricted area (maximum working range of the robot + end-effector).
- In case the gas emitted by the robot system may lead to hypoxia, the operating position should be designed to ensure that the user is not exposed to the risk.
- If the robot system is operated in a hazardous environment affecting the health and safety of the user or poses a risk, appropriate measures should be taken to provide the user with a good operating environment and prevent all predictable hazards.
- According to actual needs, the operating position should be arranged in an operating room satisfactory to the above requirements and convenient for immediate evacuation. If possible, provide emergency exits in different directions of common exits.
- Please arrange the operation panel in a safe area meeting the following conditions.
  - Outside the safety fence and inaccessible from the inside of the fence.
  - Convenient for the user to see and operate.
  - Not posing other hazards.
- Please reserve sufficient area around each device for the sake of the maintenance/repair of the robot system.
- For the safety fence, it is required to take measures to prevent the user from falling or slipping, especially for maintenance/inspection purposes. Please prepare fixed and secure handrails for the user if needed.
- Mount the robot according to its mechanical instructions.
- For the robot system, it is required to take measures to avoid trapping or conflicts between the moving parts of the robot and other stationary/movable objects.
- During mounting, please leave a sufficient space between the moving parts of the robot and surrounding structures (columns, ceiling beams, fences, etc.). The surrounding equipment required for the operation (e.g. conveyor belt for supplying workpieces) is not subject to the limit.
- To ensure that the user may not enter the hazardous area during manual operations, e.g. component mounting or disassembly, the following measures should be taken to minimize the potential risk of injury.
  - Set up mounting devices.
  - Develop appropriate protection methods.
  - Provide necessary personal protection equipment.
  - Implement strict operational guidance.
- For mounting of the robot system with the manual mode, please ensure the following minimum clearances.
  - Please consider adding safety protection devices if the functions of buildings, structures, equipment or other mechanical devices do not cause the robot to be trapped or clamped, but cannot maintain a minimum clearance of at least 0.5m or more.

- To ensure the safety of the user, the robot should stop immediately when someone is within 0.5m of a dangerous location where the robot may be trapped or clamped. The user may be subject to the risk of injury if the above conditions cannot be met.

➢ Please use a robot controller meeting one of the following conditions if it is necessary to limit the clearance by limiting the working range of the robot's basic axes (Axis 1, Axis 2, Axis 3). (Except for some models, e.g. SCARA robot)

- The mechanical brake can stop the robot operating under the rated payload and maximum speed.
- As for Axis 2 and Axis 3, there is an alternative method of manufacturing setting with the same level of safety as the mechanical brake. This alternative method complies with the limit switch in GB/T 5226.1-2019**[NOTE]** and these limit devices should be correctly adjusted or mounted.

[NOTE]

GB/T 5226.1-2019 Correspondence standard: IEC 60204-1:2016,Safety of machinery–Electrical equipment of machines–Part 1:General requirements

➢ The safety of high-altitude operations is crucial during scaffolding. It is specially noted to firmly and reliably mount the scaffolding and correctly fix safety belts. Strictly follow the steps in this robot operation manual to handle and mount the robot and controller to ensure correct and safe operation.

⚠ Warning

If our regulations are not followed during handling, the robot and controller may overturn or fall due to loss of balance, possibly causing injury or death of the user.

3.4 Connection of power supply and protective grounding

➢ Connect the power supply and protective grounding according to the instructions of each controller.

➢ Avoid dangerous accidents caused by power disconnection, power restoration after disconnection, or changes in power supply voltage. For example:

- Stoppage of safety devices.
- Dropping of workpieces or other items, etc.

➢ It is required to ensure that the robot system can safely cut off its power source and take measures to prevent misoperation (e.g. lockout or warning signs).

⚠ Warning

Before connecting the power of the controller, please protect the robot and the controller by grounding. There is a risk of electric shock in case of no grounding connection.

3.5 Relevant devices

Relevant devices mounted for the robot system should not cause harm or dangerous conditions.

The end-effector, workpiece and peripheral devices should be designed to meet relevant requirements.

3.5.1 Design requirements for end-effector

The end-effector should be designed and constructed to meet the following requirements:

- The loss or change of energy supply (such as electric, hydraulic, pneumatic and vacuum power) may not result in payload release. Otherwise, it may cause a dangerous condition.
- The static and dynamic forces generated by the payload and the end-effector are within the payload capacity and dynamic response range of the robot.
- The wrist plate (mounting flange) and accessories are correctly aligned (coupled).
- The detachable tools are firmly connected during use.
- If the release of detachable tools may cause a hazardous condition, the detachable tools are only allowed to be released in designated locations or under specific controllable conditions.
- The end-effector may bear the expected force within its expected lifespan.

If feasible, the energy can only be supplied to the end-effector but not to the robot actuator so as to eliminate faults.

3.5.2 Design requirements for workpieces

The workpieces should be designed and constructed to meet the following requirements:

- Their material or shape may not cause danger, or safety measures should be available.
- If the workpiece is very hot or cold, it is required to develop measures to prevent human contact or proximity.

3.5.3 Design requirements for other devices

Other relevant devices should be designed and constructed to meet the following requirements:

- Adopt non-hazardous materials and shapes.
- If some components may break during operation, measures must be developed to prevent them from flying around if broken.
- If an air compressor is used, it is necessary to prepare an air valve isolating the air supply to the robot.
- All peripheral devices should be grounded appropriately.
- Please fix the pipeline and take protective measures to withstand external pressure and tension.
- The (liquid or gas) pipes should be able to withstand internal/external pressure.
- It is essential to take measures to prevent dangerous conditions caused by sudden movement or high-speed jetting of the pipe if broken.
- Appropriate risk assessments should be conducted and appropriate safety measures should

be developed if power sources other than electricity (compressed air, water, thermal energy, etc.) are used in the system.

- The following safety measures should be developed to prevent dangerous conditions from occurring due to incorrect mounting of components.
  - During designing, it is important to consider how to avoid mounting errors.
  - Indicate the required markings on the components.
- The following safety measures should be developed to prevent poor connection and contact.
  - During designing, it is important to consider how to avoid poor connection and contact.
  - Indicate the markings on connectors, pipes and cables.
- When debugging peripheral devices, make sure to disconnect the power supply to the robot controller in advance.
- In case of a risk of contact with extremely high/low temperature items, it is necessary to develop safety measures to prevent such hazards.
- Consider the impact on the surrounding environment and minimize vibration and noise.
- It is necessary to develop safety measures to prevent fires or explosions after detailed investigation.
- Please consider the following to ensure safety if a laser device is used:
  - Avoid unexpected laser radiation: Take appropriate measures to prevent laser radiation at unexpected times or locations. It may include using safety switches, limiting the laser working area, setting up light barriers, etc.
  - Avoid direct/indirect effects of laser on human body: Ensure that the laser beam does not directly irradiate the human body and prevent laser from entering the eyes or being exposed to the skin. Wear appropriate personal protective equipment (such as protective glasses, protective clothing, etc.).
  - Prevent the impact on human body during maintenance/debugging: When repairing or debugging the laser device, pay special attention to preventing the direct or indirect impact of the laser on human body. In these cases, additional safety measures should be taken, such as using shielding devices, turning off the laser source, etc.

3.6 Other precautions

- It is required to ensure no danger when cutting off the power of the robot system and surrounding devices.
- The operating position of the user should meet the following conditions:
  - The operating position should allow the user to easily operate the control panel or teach pendant.
  - The operating position should be sufficiently visible and allow the user to clearly see whether some persons are inside the safety fence.
  - The operating position should provide a wide view, so that the user can accurately observe the action status and operation of the system.
  - In emergency situations, the user can quickly stop the whole or part of the system. So,

the operating position should be provided with an emergency stop button or other relevant safety equipment.

- The operating position should comply with ergonomic principles, so that the user can maintain comfort and efficiency during long-term operation.
- The operating position should comply with relevant safety standards and regulations to ensure the safety and health of the user.

- If it is difficult to confirm whether some people are inside the safety fence at the operating position or if it deems necessary during risk assessment, the following countermeasures can be taken:
  - Use visual or auditory warning devices to provide warnings and prompts before the robot starts moving.
  - The user can stop the robot system through the emergency stop button or seek refuge outside the safety fence through the emergency evacuation passage.
  - Set a method to prevent the robot system from starting in case someone is in danger.
- Set one or more operating positions to control the robot system.
- When multiple operating positions are set, prohibit the operations from other positions if one operating position is in use, except for stop control and emergency stop, to prevent confusion and operational conflicts.
- Manual operation (intervention) of restarting the robot system after emergency stop can only be performed outside the restricted range to ensure the safety of personnel.
- Mount necessary control devices at each operating position to prevent interference among the users.
- Warning devices should be easily recognizable by the users or those within the danger range.
- When the system stops, it is recommended to make adjustments, add lubricating oil (grease) and carry out repair and other work outside the danger range. If impossible, develop operational safety procedures to ensure the safety of personnel.
- Provide appropriate lighting for the robot system, especially in maintenance and repair areas, to ensure that all persons can clearly see the work area. However, it is required to present lighting devices from becoming new sources of danger, e.g. causing dizziness or other problems.
- For the robot system linked to surrounding devices, it is required to take appropriate measures to ensure that the entire system can be stopped to avoid any dangerous state when any device stops due to malfunction.
- The robot system involves various conditions (such as delivery, engineering exchange, cleaning, maintenance, etc.). So, it is very difficult to provide appropriate protective measures. In this case, please prepare appropriate safety regulations if it is necessary to disable the safety device.
- For the robot systems that can be remotely operated (e.g. communication networks), please take effective measures (e.g. key switches) to prevent other operations from causing dangerous states to the robot.
- The robot system manufacturers should prepare operating instructions complying with GB 11291.2-2013 **[NOTE]** and other standards.

- When designing robot application systems, various safety standards (e.g. ISO and GB specifications) and labor safety and health regulations should be taken into consideration.

Caution

If teaching or repair is carried out near the robot without appropriate lighting, the operator may fall due to obstacles or suffer unexpected injuries due to hitting the robot.

[NOTE]

GB 11291.2-2013 Correspondence standard: ISO 10218-2:2011 Robots and robotic devices-Safety requirements for industrial robots Part 2:Robot systems and integration

4. Safety devices

4.1 Methods for stopping robots

The methods for stopping Agilebot robots include:

Class 0 stop

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

Class 1 stop

- This is a controlled 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.

> ⚠ Warning
>
> The stop distance and time of the controlled stop are longer than those of the uncontrolled stop. When the controlled stop is adopted, it is necessary to conduct a thorough risk assessment and analysis for the whole system for the stop distance and time are longer.

4.2 Emergency stop

The Agilebot robot is provided with the following emergency stop devices:

- Emergency stop button on the upper right of the teach pendant
- Emergency stop button on the controller
- External emergency stop device (input signal)

It is required to press this device in case of danger or emergency. The robot should have the following response when the emergency stop device is pressed:

The robot stops in the form of uncontrolled stop (Class 0).

First rotate the emergency stop device for unlocking and then turn on the servo power to continue the operation.

The robot may immediately stop under any circumstances when the emergency stop button is pressed (please refer to Sections 4.1-4.3). The input signal of external emergency stop is a signal input by peripheral devices; the terminal of this signal is located inside the controller. Please refer to the maintenance manual of each controller for the actual position of the emergency stop button.

4.3 Operation mode selector

It is allowed to choose the operation mode by pressing this switch. In addition, it is possible to prevent others from changing the operation mode by removing the key.

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

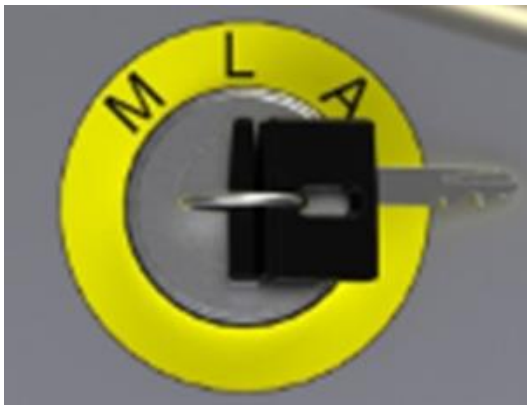


Fig. 4.3 Mode Selector

4.3.1 Operation mode

1. Manual maximum-speed mode (M)

This is a mode for robot program debuggers or operators (hereinafter referred to as the user) to debug the motions of the robot. In this mode, the user can mainly perform the following operations:

- Teach the robot.
- 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.

2. 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, the user can mainly perform the following operations:

- Teach the robot.
- 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.

3. 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, the user can mainly perform the following operations:

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

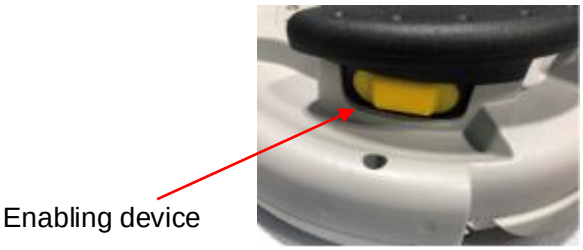
In this mode, the user is mainly prohibited from performing the following operations.

- Teach the robot.
- 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.

4.4 Enabling devices

The enabling device of Agilebot robots is an enabling button located on the back of the teach pendant. It has three positions:

- Not pressed
- Middle
- Fully-pressed (alarm position)



⚠ Caution

The robot can be operated in the manual mode only when the enabling button is held in the middle position. During teaching operation of the robot or program operation under manual mode, the release of the enabling button may trigger Class 1 stop mode; fully pressing of the enabling button may trigger a Class 0 stop mode.

4.5 Safety protection devices

In order to reduce known hazards and protect the safety of various workers, appropriate safety protection devices should be selected based on the operational tasks of the robot system, the needs of the operation process at each stage and the results of risk assessment when the robot system is designed.

The safety protection devices should be able to:

- Prevent personnel unrelated to the operation from entering the hazardous area during each operation stage; interrupt the sources of danger.
- Prevent unexpected operations.
- Accommodate or accept objects possibly falling or flying out during the operation of the robot system.
- Control other hazards generated during the operation process (such as suppressing noise, blocking laser and arc light, shielding radiation, etc.).

The safety protection devices include the following items.

- Safety fence
- Interlocked protection device
- Presence sensing device

These safety protection devices should comply with safety standards ISO and GB. Additionally, the system integrator or designer should mount these security devices according to the results of the risk assessment.

This item should be explained according to the requirements for these safety devices. For details, please refer to relevant standards, such as GB 11291.1-2011**[NOTE 1]** and GB 11291.2-2013**[NOTE 2]**

[NOTE]

1.GB 11291.1-2011 Correspondence standard: ISO 10218-1:2006,ISO 10218-1/Cor.1:2007 Robots for industrial environments–Safety requirements–Part 1:Robot

2. GB 11291.2-2013 Correspondence standard: ISO 10218-2:2011 Robots and robotic devices-Safety requirements for industrial robots Part 2:Robot systems and integration

4.5.1 Safety fence

When a safety fence is used in the robot system, the following principles should be observed:

- The safety fence must have sufficient strength and can withstand predictable vibrations from machine operation and surrounding environment.
- The safety fence must prevent access into the protected area from any place, except for entrances with interlocks or detection devices.
- Connect the safety fence to the protective earthing (PE) to prevent electric shock.
- The safety fence may not have sharp corners or protrusions, which may easily hurt personnel or damage equipment.
- Secure the safety fence to make it immovable as much as possible.
- Ensure that the safety fence is always fixed and cannot be removed without tools.
- Set the safety fence outside the maximum working range of the robot.
- It is necessary to establish a safety fence with maximum visibility in order to make the production process completely visible. (Wire meshes, grids, acrylic panels, etc. should be used.)
- Its structure should be designed to prevent detachment. So, when the safety fence is removed, the articles fixing the safety fence remain on the safety fence or robot system.
- For detailed opening dimensions and minimum grid size of the safety fence, please refer to the following safety specifications in advance.
  - GB/T 19876-2012 **[NOTE 1]**
  - GB/T 23821-2022 **[NOTE 2]**
  - GB/T 41108.2-2021 **[NOTE 3]**

[NOTE]

1. GB/T 19876-2012 Correspondence standard: ISO 13855:2010 Safety of machinery-Positioning of safeguards with respect to the approach speeds of parts of the human body
2. GB/T 23821-2022 Correspondence standard: ISO 13857:2019 Safety of machinery-Safety distances to prevent hazard zones being reached by upper and lower limbs
3. GB/T 41108.2-2021 Safety of machinery-Safety requirements for interlocking devices-Part 2:Interlocking devices with guard-locking

4.5.2 Interlocked protection device

When the interlocked protection device is used in the robot system, the following principles should be observed:

- Set the interlock to prohibit automatic operation of the robot system until the safety gate is closed.
- Fix the interlocking safety pin and socket onto the safety gate. The safety pins and sockets should meet the safety standards.
- Do not restart the automatic operation of the robot system while only the safety fence is closed. Set the restart of automatic operation after careful operation on the console.

- Keep the gate locked until the risk of injury disappears (with interlocking protective devices), or stop the robot in motion when opening the gate (interlocking protective devices).

For detailed information on interlocking devices, please refer to GB/T 41108.2-2021**[NOTE]**.

If completely entering the safety protection area through the safety gate, it is recommended to mount the devices to prevent accidental closing of the gate.

Please note that the interlocking action of the protective device (e.g. stopping the dangerous action of the robot system) should not cause other hazards (e.g. releasing hazardous materials into the work area).

[NOTE]

GB/T 41108.2-2021 Safety of machinery-Safety requirements for interlocking devices-Part 2:Interlocking devices with guard-locking

4.5.3 Presence sensing device

The presence sensing device is often used in the safety protection of the robot system and the following principles should be followed during its design:

- The presence sensing device should be designed and arranged to ensure that nobody can enter or no part of the body can extend into the restricted space until the sensing device is functional. To prevent any person from bypassing the presence sensing device and entering the hazardous area, it is required to combine the presence sensing device with the fence.
- When designing and selecting the presence sensing device, it should be considered that its function is not affected by any environmental conditions (such as humidity, temperature, noise, lighting, etc.) where the system is located.
- When the presence sensing device is functional, the robot system can be restarted from a stop state to a running state as long as no other hazard may be caused.
- When the motion of the robot is resumed, it is required to remove the blockage in the sensing area and the robot system should not be restarted for automatic operation at this time.
- There should be a lamp indicating the operation of the presence sensing device. Moreover, the mounting position of the sensing device should be conspicuous. The lamp can be integrated into the presence sensing device or as a part of the robot's control interface.

4.6 Entering the safety fence

Here, an example is given to illustrate the steps for safely entering the safety fence.

In addition, only the "Robot Engineer" and "Maintenance Engineer" can enter the safety fence. Except for these persons (including operators), others must not enter the safety fence.

Steps for entering the safety fence:

Status: The robot is running in AUTO mode.

1. Press the stop button on the robot or input a stop signal to stop the robot.
2. Use the operation mode selector to switch the operation mode from AUTO mode to M mode or L mode.

3. To prevent others from switching operation modes, remove the key of the operation mode selector.

4. Open the safety gate to trigger the safety signal (a safety pin on the safety gate is connected to the safety signal of the controller).

The user entering the safety gate is required to properly set the operation mode and take away the key of the selector.

4.7 Operation within the safety fence

In order to teach the robot and others, please observe the following precautions during the operation within the safety fence.

- Confirm that the robot has completely stopped before entering the fence. Never enter the fence while the robot is in motion. If the robot is in motion, control or smoothly stop the robot by the stopping method of the waiting robot before entering the fence.
- If getting to the inside of the fence, you should enter from the safety fence and ensure that the robot is in a stop state.
- To remind the operator working within the safety fence, please clearly mark the area where the work is being carried out. When teaching or testing a robot, the robot may accidentally move. Please take care to avoid the robot's position for teaching in dangerous conditions.
- Hold the enabling device surely with your hand during operation.
- If two or more persons are working together, the person using the teach pendant should take charge, while the other should follow the instructions of the person in charge. Never operate the external operation panel or the robot's teach pendant without the command of the person in charge.
- In order to prevent potential hazards caused by sudden behavior of the robot, the user should always ensure that there is a shelter around.
- Keep the passage clear and avoid blocking the passage or obstructing the escape of others.
- Continuously monitor the robot during jog, test run, etc.
- If dangerous, the user should immediately press the emergency stop button to stop the robot. If possible, ask others to continuously monitor outside the safety fence and keep ready to press the emergency stop button at any time.
- When closing the safety fence, please confirm that nobody is inside the fence.
- Take care not to place tools on movable areas or peripheral devices.

 Warning

1. Set and follow the procedures for entering the safety fence as needed. Otherwise, it may be pinched by the robot, causing serious injury or death.

2. Especially during teaching or maintenance, please note to prevent unrelated personnel from unconsciously entering the safety fence. Otherwise, it may be pinched by the robot arm, causing serious injury or death accident.

5. General precautions

This chapter explains safety requirements for the following conditions.

- Mounting (5.1)
- System composition and functional test (5.2)
- Precautions for robot body (5.3)
- Program (5.4)
- Program verification (5.5)
- Auto run (5.6)
- Resolution of common faults (5.7)
- Safety of maintenance engineers (5.8)
- Maintenance (5.9)
- Dismantling and scrapping (5.10)
- Other precautions (5.11)

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

1. Set and follow the procedures for entering the safety fence as needed. Otherwise, it may be pinched by the robot, causing serious injury or death.

2. Especially during teaching or maintenance, unrelated personnel must not enter the safety fence. Otherwise, it may be pinched by the robot, causing serious injury or death.

5.1 Mounting

Mount the robot system according to the manufacturer's requirements and determine safety protection measures based on hazard analysis and risk assessment. The user should carefully confirm safety requirements and check whether the safety protection devices are mounted correctly and operated normally before use.

5.2 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.

5.2.1 Designation of limited space

All robots or robot systems should be provided with safety protection devices. If 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.

5.2.2 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.

5.2.3 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 (Agilebot). 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 teach pendant 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 payload and required speed.

5.2.4 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.

5.3 Precautions for robot body

1. The components of the robot system should be kept clean and used in an environment uneasily affected by oil, water, dust, etc.
2. Never use cutting fluids and cleaning agents with unknown properties.
3. Use limit switches or mechanical brakes to limit the operation 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 cables outside the robot, take care to avoid obstructing the movement of the robot.
   - For the models with the cables exposed out of the robot, do not make modifications hindering the movement of the exposed parts of the cables (e.g. adding protective covers or fixing external cables).
   - When mounting external devices on the robot, it should be noted to avoid interference with other parts of the robot.
5. For the robot in motion, frequent power-off and stop operations, e.g. by pressing the emergency stop button, may lead to robot malfunctions. It is required to avoid power-off and shutdown configurations in daily conditions (see bad examples).

   Usually, it is allowed to perform power-off and shutdown operations after the robot slows down and stops due to such reasons as holding and cycling. (For details on stop methods, please refer to the “Methods for Stopping Robots" for safe use.)

   Bad examples are as follows:

   - Every time a defect occurs, the emergency stop is used to power off and stop the operating robot.

- When corrections are needed, open the gate of the safety fence to activate its safety switch, thereby powering off and stopping the operating robot. Frequently press the emergency stop button to stop the production line.

- The area sensor and foot pad alarm switch connected to the safety signal are also frequently activated in normal times, causing the robot to power off and stop.

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.

5.4 Create A Program

Try to execute the “Create a program” in a safe and secure area in the absence of anyone. Appropriate safety protection measures should be taken if a program is created in case of some person in the safety protection area.

Those unrelated to the teaching task should not enter the safety fence. If caught by the robot during teaching, it may possibly cause serious injury or death.

5.4.1 Before creating a program

The following requirements should be met before creating a program.

- The robot engineer should receive training on the robot in the same form as the actual robot system used and be proficient in the recommended teaching steps (including all safety protection measures).
- The robot engineer visually inspects and confirms no dangerous external conditions within the robot system and safety protection area.
- If the teach pendant is used to create a program, it is required to test the teach pendant to confirm its normal function.
- Before creating a program, repair all obstacles or malfunctions in the robot system.
- Before the robot engineer enters the safety protection area, mount all necessary safety protection measures in the designated positions and confirm that they are functioning normally.
- Before the robot engineer enters the safety protection area, set it to the teaching mode and take measures to prevent third parties from starting automatic run.
- When using the operation panel and teach pendant, gloves may cause operational errors. So, it is important to remove the gloves before operation.

5.4.2 When creating a program

When creating a program, only robot engineers can enter the safety protection area and the following conditions should be satisfied as well.

- Make the robot system only controllable by the robot engineer within the safety protection area. (In M/L mode, the robot can only be operated through a teach pendant. The robot engineer should set an appropriate speed to allow the robot to move.)

- Please use the button on the teach pendant correctly.
- The robot system should not respond to any external commands or situations causing dangerous conditions.
- If the actions of other devices within the safety protection range may cause dangerous conditions, please prohibit such actions or set them to only be controlled by the robot engineer. When in the state controlled by the robot engineer, please set it to the mode unrelated to the operation of starting the robot and only executable by the robot engineer.
- All emergency stop devices must operate normally in the robot system.

5.4.3 Restore to Auto run

Before starting the auto run of the robot system, the robot engineer should restore the temporarily stopped safety protection device to the original effective state.

5.5 Program verification

If it is a necessary part of the verification step to visually confirm that the robot system responds to the program, please ask everyone to exit the safety protection area before execution. Please follow the following instructions when the program verification should be carried out with an operator in the safety protection area.

- Firstly, perform the program verification at a safe operating speed. Special attention should be paid when the magnification is specified in the program.
- Please follow the following instructions if it is necessary to confirm the robot's action at a full speed (running speed).
    - Only the robot engineer can switch from a safe operating speed to a normal operating speed after careful operation.
    - Keep the operators in the safety protection area in such a state that they can use the enabling device or an equivalent safety device at any time.
    - Safe operation procedures should be established in advance to minimize the exposure of the operators in the safety protection area to hazards.
- After the program ends, make sure to perform the test run according to the following steps.
    1. Execute at least one motion command cycle in the single-step mode at a low speed below 250mm/s.
    2. Execute at least one cycle in the continuous operation mode at a low speed below 250mm/s.
    3. Raise the speed step by step and execute multiple cycles continuously according to the actual situation until the full speed, to confirm that no abnormalities occur.
    4. Confirm no errors in the program through the above test run and then execute the program in the auto mode.
- The robot engineer must evacuate outside the safety fence during automatic operation.

5.6 Auto run

It is allowed to perform the auto run when all the following conditions are met.

- The designed safety protection device is functioning normally in the designated position.
- Nobody is in the safety protection area.
- Appropriate safety operation steps have been prepared and should be observed.

⚠ Warning

Before auto run, make sure that nobody is inside the safety fence. Otherwise, the people inside the fence may be caught by the robot, resulting in serious injury or death.

5.7 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 start the robot with an enabling device as needed.
- Please establish the safe operation steps in advance to minimize the possibility of danger for the users within the safety protection area.

5.8 Safety of maintenance engineers

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

1. Never enter the working range 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. (According to Section 4.5)
3. When it is necessary to enter the working range 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.
4. When entering the safety fence, carefully inspect the entire system and confirm no danger. If it is necessary to enter the fence in case of any danger, it is required to grasp the state of the system and be very careful when entering.
5. When repairing the pneumatic system, make sure to release the air pressure and reduce the pressure in the pipeline to 0 in advance.
6. Before maintenance, it should be confirmed that the robot or peripheral devices are not in a dangerous state and free of any abnormalities.
7. Never perform auto run in case of some people within the working range of the robot.
8. 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.

9. 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.

10. 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.

11. 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.

12. During component replacement or reassembling, it is required to avoid the adhesion or mixing of foreign objects.

13. 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 main circuit breaker of the controller in advance in order to prevent electric shock. In case of two controllers, please disconnect the power supplies of respective circuit breakers.

14. The replacement parts must be those specified by us. The use of other parts may lead to incorrect operation and damage. Especially if fuses and other components with different ratings are used, it may not only cause damage to the internal components of the controller, but also cause a fire. Therefore, do not use them.

15. When restarting the robot system after maintenance, it is required to note whether there are people within the working range and whether there are any abnormalities in the robot and peripheral devices.

16. When disassembling the motor and the brake, a crane should be used for lifting before dismantling to prevent arms from falling off.

17. 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.

18. 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.

- Servo motor
- Interior of controller
- Gearbox
- Wrist unit
- Arm unit

19. 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.

20. 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.

21. 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.

22. During working at height, please ensure secure scaffolding and fasten the safety belt.
23. After maintenance, thoroughly clean oil, water, debris, etc. scattered on the ground around the robot and inside the safety fence.
24. The components (bolts, etc.) removed during replacement should be correctly remounted to original positions. If it is found that the components are insufficient or excessive, they should be confirmed again and mounted correctly.
25. The following precautions should be taken when it is necessary to start the robot as a last resort during maintenance.
26. Make sure to ensure an escape route. Only start the operation after understanding the condition of the whole system to prevent the exit path from being blocked by the robot and peripheral devices.
27. Note whether there are dangers around and get ready at any moment so that the emergency stop button can be pressed when needed.
28. 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.
29. After component replacement, it is necessary to conduct testing and operation according to the method specified. In this case, the user must operate outside the safety fence.

5.9 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.

The steps for entering the safety fence are described in the following when maintenance must be carried out within the safety protection area.

Warning

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

Enter the safety fence for maintenance

1. Stop the robot system.
2. Cut off the power supply of the robot system. Lock the main circuit breaker during maintenance to prevent the power from being accidentally connected.

Please make sure to confirm the following in advance if it is necessary to enter the safety fence without cutting off the power supply of the robot system.

- Check the robot system to confirm that there is no state causing incorrect action.

- Check if the teach pendant is operating properly.
- In case of any damage or incorrect actions, complete necessary modifications and perform retesting before the operator enters the safety protection area.

3. Enter the safety fence (please refer to Section 4.5).
4. Check whether the safety protection system is effective after maintenance. Restore the system to the original effective state if it is interrupted by maintenance.

5.10 Dismantling and scrapping

Please contact us when dismantling or scrapping the Agilebot robot.

Warning

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.

5.11 Other precautions

The motors without brakes are used for some models of robots. For these models, disconnection of the servo power may cause the robot to act in the direction of gravity at a low speed. Please specially not the action of the robot if you are using a robot without a motor brake. Otherwise, it may cause personal injury or equipment damage.

Caution

Properly dispose the batteries used for storage backups on the robot. During discarding, the battery may be broken or catch fire if the battery terminals are short circuited.

6. Routine maintenance

6.1 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 teach pendant
- Damage to connecting cable
- Lubricating state
- Emergency stop function
- Safety mechanism of safety fence (when the safety fence is mounted)
- Vibration and noise of robot actions
- Functions of peripheral devices
- Looseness of connectors
- Air pressure

6.2 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 teach pendant 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.

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