

Multi-function Robot(HighMate C20) Operation Manual



We appreciate your trust and recognition of our company, as well as the use of our HighMate C20 Cargo Hold Cleaning Robot.

This manual is prepared and revised by the Research and Development Department of Beijing TimeRiver Technology Co., Ltd (RobotPlusPlus).

To the extent of permitted by Chinese laws and regulations, Beijing TimeRiver Technology Co., Ltd reserves the right to interpret this manual.

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1.1.0	New model update	2025/01
1.1.1	High pressure pump and related content; electric nozzle update	2025/03
1.2.0	New model update. System intro, maintenance, transport, storage, exploded view, schematic diagram update	2025/07

Equipment Information

List of Equipment:

Product Name	Model	Quantity
Mulit-function Robot	HighMate-C20	1 pc
Control Cabinet	RPP-MW-SIC-G	1 pc
Remote Control	RPP-WRC-V34.03	1 pc
Fall Arrestor	G-J-30	2 pcs
Power Cable	CBX-048/VJ1.002	1 pc
Power Cable	CBX-048/VJ2.048	1 pc
Power Cable	CBX-220/V02.015	1 pc
Extension Arm	SIC210-510.000.A	1 pc
Unloading Tool	SIC210-610.000.A	1 pc
Tool Kit	RPP-GJTZ-SIC.B	1 set

Product Information:

Robot Serial No	MFG Date	_____
Cabinet Serial	MFG Date	_____
Remote Serial	MFG Date	_____
Certificate No	MFG Date	_____

Declaration

Before using/operating our product, please read this manual carefully and make sure a comprehensive understanding is achieved in order to use the product correctly and safely, hence preventing any property loss or accidents due to human errors.

All content in this manual should not be reproduced or disseminated in any forms without permission.

All parameters and designs are subject to changes without notice.

We have tried to include as many descriptions of situations as possible in this manual. For those situations that are not necessary and not possible, we did not include them for various reasons.

Therefore, for those situations not mentioned or described in the manual, it can be considered 'impossible'.



Before using/operating our product, please read this manual carefully and make sure a comprehensive understanding is achieved in order to use the product correctly and safely, hence preventing any property loss or accidents due to human errors.

Preface

During the design and manufacture process of HighMate C20 Cargo Hold Cleaning robot, it complies with the following specifications and standards:

- No toxic or harmful materials are used in the manufacturing process of this product
- The environmental protection in the manufacturing process of this product is strictly implemented in accordance with ISO14001 standard.
- ISO 11291.1-2011 Robots and robotic devices — Safety requirements for industrial robots.
- GB/T 5226.1-2019 Electrical safety of machinery -- Electrical equipment of machines -- Part 1: General requirements.
- GB/T 15706-2012 Safety of machinery -- General principles for design -- Risk assessment and risk reduction.
- GB/T 8196-2018 Safety of machinery -- Guards -- General requirements for the design and construction of fixed and movable guards.
- GB 4208-2017 Degrees of protection provided by enclosure (IP code).
- GB/T 12572-2008 Universal requirements and measurement methods of parameters for radio transmitting equipment.

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1. Product Overview

1.1 Units

mm	Millimeter	cm	Centimeter
m	Meter	kg	Kilogram
MPa	Megapascal	bar	Pressure unit, equals to the force of 1 kilogram
kW	Kilowatt	V	Volt
A	Ampere	s	Second
min	Minute	h	Hour
m²/h	Meter square per hour	m/min	Meter per minute
L/min	Liter per minute	°C	Degree Celsius
Hz	Hertz	MHz	Megahertz

Other units not specified in the table please check relevant standards.

1.2 Special Terms Explanation

LWH	Length, Width, Height
Non-consecutive Obstacle Crossing Ability	Obstacles should not be consecutive arranged, with spacing greater than 50 mm
Cleaning Unit/Module	Cleaning functioning device
Swing Module	Device that allows the cleaning module to swing
Nozzle	Cleaning tool/part
Water Line	Waterjet that come out from the nozzle

2. System Introduction

HighMate C20 is an innovative, smart and efficient cargo hold cleaning solution developed by RobotPlusPlus.

HighMate C20 robot system has excellent performances with advanced technology, and brings evolution and breakthrough in cargo hold cleaning field. It will significantly improve the quality and efficiency of cleaning operation, and motivate the whole industry.

The cargo hold cleaning robot is used in regular cargo hold area cleaning and maintenance operation. Cargo holds after cleaning can help to secure the quality of the cargo, prevent cross pollution and get rid of possible pollutants and odors. At the same time, it helps to improve the safety of the vessel by decreasing the danger of fire and explosion, and avoid structure corrosion and damage.

2.1 System Overview

The main features of HighMate C20 developed by RobotPlusPlus are as follows:

- Magnetic platform, suitable for steel surfaces cleaning operation such as cargo hold areas.
- Remote control, operation on the ground to eliminate working at height.
- High pressure waterjet technology allows high efficiency cleaning.
- Simple to use and operate.
- Reduce the use of basket, scaffoldings and cherry-pickers, lower construction cost.
- Effectively reduce or avoid dangerous manual work in the cleaning process.
- Excellent curvature adaptability, one robot can cross both internal and external corners hence achieve almost entire cargo hold cleaning.

2.2 System Composition

The cargo hold cleaning robot system consists of the following parts, as shown by Figure 2.1:

- Cargo hold cleaning robot × 1
- Fall arrestors × 2
- Remote control × 1
- Control cabinet × 1
- Extension arm × 1
- Power cable × 3
- High pressure pump × 1

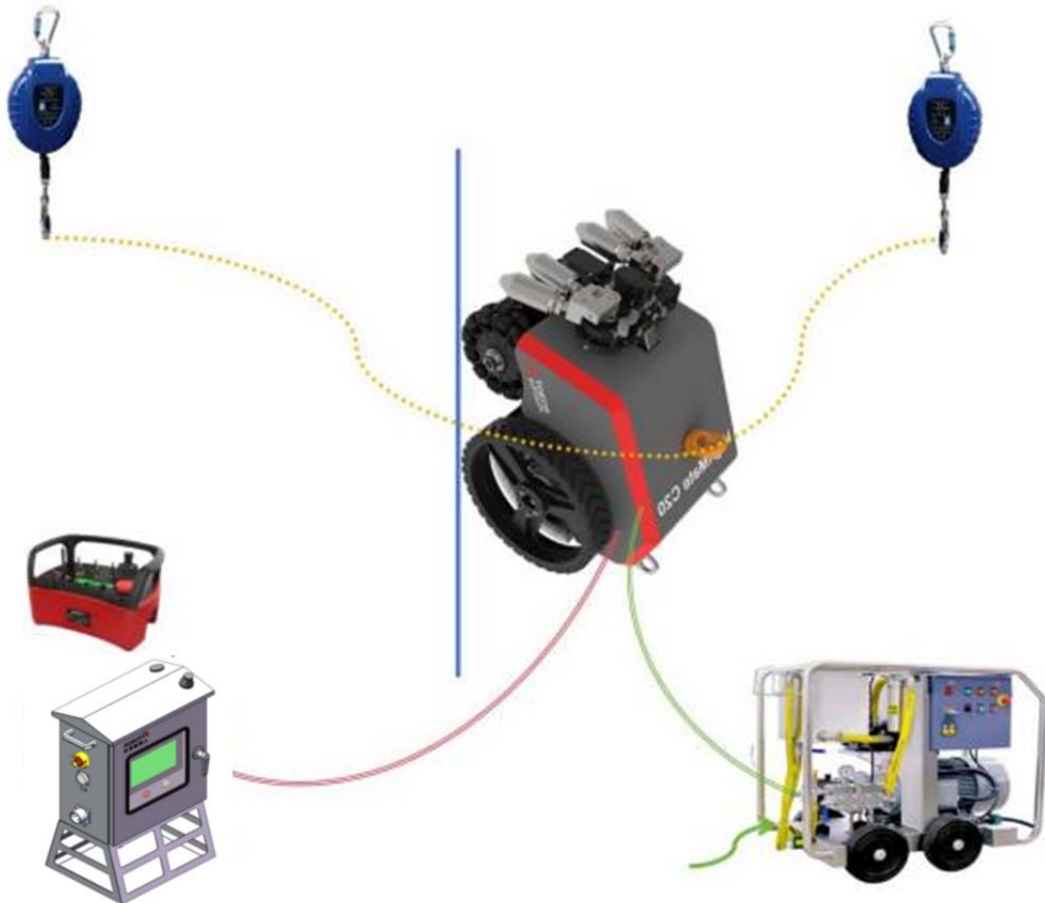


Fig 2.1 System Composition



Cargo Hold Cleaning Robot



Fall Arrestors



Remote Control



Control Cabinet



Power Cable



Extension Arm



High Pressure Pump

Fig 2.2 System Composition

2.3 Technical Specifications

Cargo Hold Cleaning Robot Specifications

Item	Specifications
Dimension (LWH)	596 × 434 × 453 mm (Nozzle) 552 × 942 × 960 mm (Arm)
Weight	65 kg
Voltage (Robot)	DC 48V
Obstacle Crossing	Non-consecutive obstacles with height ≤ 15 mm Steel surface with radius larger than 5m Can cross corners between 110~250 degrees
Speed	0~25 m/min stepless adjustable
Protection Level	IP65, key parts IP68
Working Width	580 mm
Production Rate	≥ 500m ² /h

Cargo Hold Cleaning Robot System Specifications

Item	Specifications
Communication	Remote control, with range 80m Frequency 433 MHz
Cabinet Power Supply	1.5 kW @ 100V – 240VAC, 50/60 Hz
Pump Power Supply	380V / 440VAC (on board) 50/60 Hz
Pump Pressure	Maximum 500 bar / 50 MPa
Water Consumption	30 L/min
HP Pump Dimension	1440 × 800 × 1300 mm
HP Pump Weight	430 kg
Fall Arrestors	Lock speed: 2m/s Load: 150 kg Length: 30 m

2.4 Environment Requirements

- Ambient Temperature: $-25^{\circ}\text{C} \sim +55^{\circ}\text{C}$
- Relative Humidity: 5% ~ 90%
- Altitude: Less than 1000m. If used between 1000m ~ 4000m, it should be used derated.
- Water: Fresh water, with particle diameter < 40 micron.
- Acid-base Tolerance: Avoid using in acid or alkaline environment.

2.5 Technical Principles

HighMate C20 Cargo Hold Cleaning Robot developed by RobotPlusPlus consists of robot, control cabinet, remote control and other supplementary devices. The robot is the key part of the system, used to achieve the function of cleaning the hold area.

The robot has adopted advanced sensors and smart algorithms for controlling its movements. The sensors are like the eyes of the robot, that enables the robot to sense the surroundings and status of the cleaning target clearly, and make it able to pass through the complicated cargo hold area flexibly, and achieve an efficient, comprehensive and precise cleaning.

The remote control is used with the robot as the ground control terminal. The remote control allows the operator to control the robot in a safe distance, achieve a higher-precision control and visualization of the cleaning job, and ensure a smooth operation.

2.6 Application Scenario

HighMate C20 cargo hold cleaning robot is designed based on the demand in cleaning the cargo hold area of bulk carries, but also can be used for other scenarios as well:

- Cleaning of ship hull during shipping.
- Cleaning the marine growth during dry docking.
- Cleaning of the surfaces of storage tanks.
- Cleaning of the surfaces of offshore platforms.
- Cleaning of the surfaces of other large steel structures or projects.

3. Safety Instructions

3.1 Personal Safety Requirement

- Metal items (keys, watches, etc.) are prohibited. A metal detector check is required before work.
- People with pacemakers or medical implants are strictly prohibited from entering within a 5-meter radius of the magnetic field.
- Do not wear magnetic material spectacle frames (resin lens goggles are recommended).
- Do not wear chemical fiber work clothes (they may melt and stick to the skin when exposed to high temperatures).
- Wear anti-slip insulated boots (to prevent electric leakage risks).
- Do not roll up sleeves or trouser legs when operating (to prevent high-pressure water jets from entering).
- Wear protective goggles, safety shoes and safety helmets during work.
- Do not wear loose or torn clothes. Remove all jewelry before work.

3.2 Product Safety Instruction

Any changes or add-ons that may affect the safety of the robot shall not be made without permission. In particular, any safety devices or major load-bearing components should not be adjusted, changed or welded.

It is advised to purchase spare parts from the manufacturer or purchase the parts that meets the technical requirements and specifications. The maintenance period described in the manual should be strictly followed, and the operation should meet all relative rules and regulations.

For proper maintenance, please use the tool provided by the company. Each time after maintenance procedure, please keep all the tools and parts to avoid missing.

On site, fire extinguishers must be placed nearby. Operators should be skilled in the use and operation of fire extinguishers.

3.3 Operation Safety Instruction

All operators of this robot must go through detailed application training, and strictly carry out the inspection process before using the equipment. The inspection and maintenance of the corresponding devices should be carried out according to the specified period.

The work or adjustment on the electrical components of the equipment should only be performed by skilled electricians or trained personnels, under the guidance and supervision of electrical engineering regulations.

Inspect the robot visually at least once a day for any damage or defect. In case of failures and errors, the robot must be shut down and fixed immediately. Do not start the robot until all failures are resolved.

3.4 Maintenance Safety Instruction

Before any maintenance or repair work is carried out, the robot should be placed at a safe position in order, the power supply need to be cut-off in case any accidental power on of the robot.

The specified inspection and maintenance period stated in this manual should be strictly followed, as well as the information about spare parts and system update.

All operators need to be informed that it is strictly prohibited to operate the robot during the maintenance and repair process. Any violation of this rule may lead to serious accidents, resulting in injuries, death and damages of the machines, and bring significant danger and loss to the operation. At all times, safety and relevant rules and regulations should always be the first priority, which ensure the maintenance and repair work can be done smoothly and efficiently.



In all work related to the use, maintenance and adjustment of the robot, the start-up and shutdown procedures must be carried out in accordance with the operating instructions.

3.5 Medical Treatment for Emergency Situations

To minimize the harm of water jet injury accidents and reduce losses to the lowest extent, and to protect the safety and health of employees, the following precautions are hereby provided:

The degree of injury caused by water jet impact varies depending on the distance between the jet and the human body, the angle of impact, the duration of impact, the nozzle diameter of the jet, the pressure level during jetting, and the nature of the dirt on the surface of the object being cleaned.

When a water jet strikes a person vertically at a distance of 200 mm with a pressure greater than 15 MPa, it will cause a deep penetrating wound with small holes and inject sewage into the body. When a water jet strikes a person vertically at a distance of 500 mm with a pressure greater than 20 MPa, it will cause a deep penetrating wound with small holes and inject sewage into the body. When the water jet strikes the human body at a certain angle, it can cause both deep penetrating wounds and erosive open wounds. When the jet pressure is greater than 100 MPa and causes injury to the human body, it is necessary to carefully examine whether the deep tissues and bones have been injured. When the jet "sweeps" or "scrapes" across the human body, it forms erosive open wounds. The closer the distance between the jet and the struck human body, the longer the impact duration, the larger the nozzle diameter of the jet, and the higher the pressure level, the more severe the injury to the human body will be. The injured person struck by the jet may not show the full extent of the wound, especially the internal damage. The depth of the wound penetration is difficult to determine. Sometimes, although the surface wound is small or even does not bleed, a large amount of sewage may have penetrated through the tiny wound into the skin, muscles, and internal tissues.

Since the cleaning water contains bacteria and the dirt on the cleaning object can dissolve in water, when the jet penetrates the human body, it may carry some contaminants. These harmful substances can enter deeper parts of the human body with the jet. If the cleaning is not thorough, infection may occur. Therefore, medical personnel must thoroughly clean the wound, and if necessary, the wound should be incised.

After a water jet injury accident occurs, the injured person should be immediately sent to the hospital, and the specific circumstances of the injured person should be explained to the doctor as much as possible, especially emphasizing the characteristics of the penetrating damage of the water jet and the characteristics of the invasion of contaminants and bacteria. After a water jet injury accident occurs, the wound should first be bandaged with a clean item to stop bleeding and the injured person should be observed until medical examination is arranged.

3.6 Operation Environment Management Tips

- Remove any loose items from the working area, such as garbage and oily rags.
- Do not participate in or tolerate any playful or rough behavior in the working area.
- Ensure that after completing the equipment maintenance work, all tools, parts and rags are removed from any rotating parts.

3.7 Special Scenarios

- Wear 5000V voltage-resistant insulated boots (with water-draining grooves and anti-slip patterns on the sole).
- Use silicone-sealed protective goggles (to prevent rainwater from affecting vision).
- Add insulating sleeves to all metal tools (contact resistance $\geq 100\text{M}\Omega$).
- Operators should wear anti-static wrist straps (grounding wire length ≤ 1.5 meters).
- Do not perform operations during heavy rain.

4. Part Introduction

4.1 Robot Platform

Platform is the basic structure supporting the frame, motion system and other components of the robot. It is the major part in charge of the movement, load ability and stability. For movement, it allows the robot to move flexibly around different scenarios with precision. For load ability, it withstands the overall weight of the robot, electric components and working modules, hence keeps an intact structure. For stability, the reasonable design leads to perfect performance in movement, which largely decrease the shaking and turbulence during motion and hence ensures the precision and accuracy of the motion. Therefore, it helps to keep an efficient and smooth operation.



Fig 4.1 Platform Structure

4.1.1 Driving Module

It is the power source of the robot. Advanced motors provide strong and stable power to the platform, achieving precise and flexible control in complicated paths.

4.1.2 Driving Wheel

Wheels made of natural rubber material, which provides a strong friction force in contact with the surfaces. Regardless of vertical surfaces or topside reverse surfaces, the wheels guarantee a stable support for the robot to be adapted to different complicated scenarios.

4.1.3 Control Unit

It is the key of the platform. Advanced algorithm and technologies allow the unit to control the speed, direction and attitude accurately, so that the robot can operate with appropriate speed on expected routes stably.

4.1.4 Driven Wheel

The omni-directional design makes the wheel able to move in both axial and circumferential directions, which gives the robot better moving ability and direction conversion ability.



Fig 4.2 Driven Wheel Structure

4.1.5 Swing Module

This module can swing in the axial direction of the moving direction of the robot, which helps the robot to keep close to the working surface especially on curved areas, and helps the robot moves smoothly and stably.

4.1.6 Magnets

Magnets chosen with careful calculation will provide powerful permanent magnetic force to the robot. Its unique design not only makes the robot able to be attracted to the surface firmly, but also allows it to cross-over the internal and external corners smoothly.



Fig 4.3 Magnets Structure

4.1.7 Protection Frames

The protection frame is made of high-strength materials and features robustness and shock resistance. It can effectively prevent external objects from colliding and impacting the robot during its operation, providing reliable safety guarantees for the core components and operating system of the robot, reducing the risk of equipment damage, ensuring the stable and continuous operation of the robot, and thereby guaranteeing work efficiency and quality.

This component plays an important role in the lifting operations of robots. Its durable design is specifically used to achieve safe lifting of the robot and is a key part connecting the speed difference self-control device. Through a stable connection with this device, the lifting ring can ensure the smooth and safe operation of the robot during the lifting process, effectively preventing accidents of falling, and providing reliable protection for the transportation of the robot.



Fig 4.4 Protection Frame and Hoisting Hook

4.2 Cleaning Module

Cleaning module of this robot uses high pressure water as the cleaning medium. The module is equipped with advanced tool to adjust the cleaning angle accurately, to achieve the comprehensive cleaning of dead angles at different positions. When dealing with complicated cleaning tasks and diversified scenarios, adjustable nozzle cleaning ensures an ideal cleaning result and provides strong supports in cleaning operation.

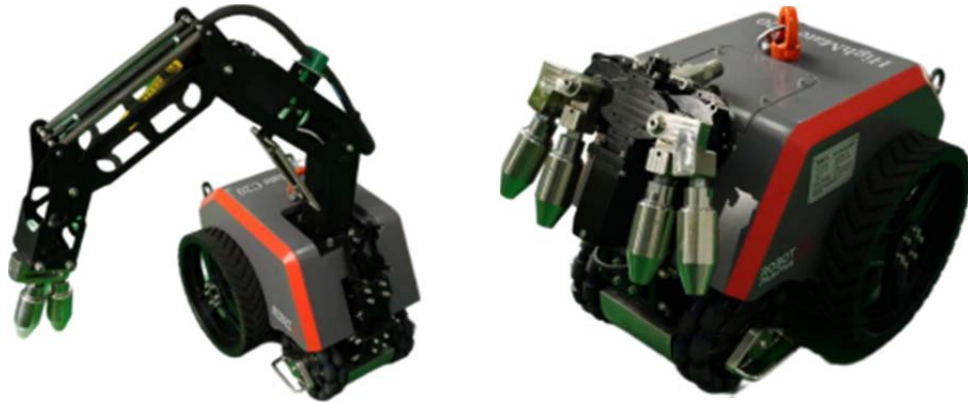


Fig 4.5 Cleaning Module Structure

4.2.1 Rotation Nozzle

The electric nozzle is made with advanced technology and high-quality materials. It can precisely and stably provide continuous high-pressure water to each nozzle, ensuring that the nozzle maintains a strong jet pressure and stable water output during operation. Its internal water channels are meticulously designed to enable the stable transmission of water. The electric rotation nozzle is driven by an internal motor to rotate the nozzle, and its rotatable feature allows it to flexibly adjust the angle and position, enabling efficient cleaning of the sides, backsides, and hard-to-reach areas of the frames. By concentrating and precisely spraying high-pressure water, it can quickly and effectively impact the dirt, impurities, and contaminants on the surface to be cleaned.



Fig 4.6 Electric Nozzle

4.2.2 Extension Arm

The extension arm is equipped with a cleaning module specially designed for areas that the cleaning robot cannot reach directly. This cleaning module can be directly installed on the robot and uses the same high-pressure water pipe interface for convenient connection. The arm has one electrically controlled degree of freedom, which is used to adjust the height of the extension arm's nozzle. Additionally, two manual adjustment degrees of freedom are designed to adjust the orientation angle of the nozzle.



Fig 4.7 Extension Arm

4.3 Electric Control Cabinet

The control cabinet serves as the ground-based control terminal of the robot and acts as the central hub for all robotic communication systems. It is paired with a dedicated remote controller under a strict one-to-one matching requirement. To assist customers in identification, both units are individually marked prior to delivery. For ongoing operations, we recommend that customers apply their own labeling (e.g., color-coded tags, custom numbering) to prevent mispairing — which could lead to operational failures or safety hazards.



Fig 4.8 Control Cabinet Structure

4.3.1 Installation & Environmental Requirements:

- **Placement Location:** Install the control cabinet in an open, well-ventilated area away from metallic walls or large conductive surfaces to avoid signal interference.
- **Antenna Positioning:** Ensure the antenna is mounted at sufficient height (minimum 1.5 meters above ground) and unobstructed by metal objects or dense structures to maintain optimal wireless performance.
- **Stability:** Place the cabinet on a flat, stable surface. Use leveling feet if necessary to prevent tilting or vibration during operation.
- **Weather Protection:** Although designed for industrial use, the cabinet is not fully waterproof. During heavy rain or high-humidity conditions, cover the unit with a weatherproof canopy or relocate it indoors to prevent water ingress.

4.3.2 Electrical Specifications:

- Input Power: 220V AC $\pm 10\%$, 50/60Hz
→ Ensure the power plug is securely connected and grounded. Loose connections may cause arcing or equipment damage.
- Output Power: 48V DC, maximum total output power: 1500W
→ Do not exceed rated load. Overloading may trigger protection circuits or reduce system lifespan.
- Cable Management: All input/output cables should be routed neatly and secured to prevent tripping hazards or accidental disconnection.

Safety Note: Always disconnect power before performing maintenance or cable adjustments. Only qualified personnel should handle electrical connections !

4.4 Remote Control

Remote control is the special device for cargo hold cleaning robot C20. It uses wireless communication to control the robot, and the maximum range of the wireless signal is 80 meters in actual practice. The robot can be operated freely within this range, even in complicated cargo hold environment, the control order will be delivered to the robot accurately and hence ensure an effective cleaning operation.



Fig 4.9 Remote Control

4.5 Power Cable

There are three power cables in the system. One of the cables connects the power source to the control cabinet, and has a length of 15 meters, AC. One cable connects the control cabinet to the robot, and has a length of 48 meters, DC. The last cable connects the cable reel to the control cabinet which is 2 meters DC.



Fig 4.10 Power Cable



The standard cable included is 50 meter-long. If operate the robot exceed this range, it will cause pulling and dragging the cable which may lead to serious consequences.

4.6 High Pressure Pump

The high-pressure pump can provide water with maximum 500 bar (50 MPa) and 30 L/min flow rate. At the same time, high-pressure waterjet gun included in the pump set can be used to clean the areas not available for robots.

The pump is designed to meet the demanding cleaning requirements and environmental challenges. All the pumps and all the components in contact with water are made of corrosion-resistant materials, including ceramic pistons, long-lasting seals and valves. Together, they ensure the long lifespan and durability of the water gun.

Item	Specification
Model	RPP-EC-50-30
Dimensions (L×W×H)	1440 × 800 × 1300 mm
Weight	520 kg
Maximum Pressure	500 bar / 50 MPa / 7250 Psi
Maximum Flow Rate	30 L/min
Power Supply	3 Phase, 380/440VAC, 50/60 Hz
Rated Power	30 kW
Maximum Inlet Water Temperature	50°C
Rate Rotational Speed	1750 rpm



Fig 4.11 High Pressure Water Pump

4.7 High Pressure Water Hose

The high-pressure thermoplastic hoses are suitable for the high-pressure water cleaning industry. They are mainly composed of an inner rubber layer resistant to liquids, a middle rubber layer, a steel wire reinforcing layer, and an outer rubber layer. The inner rubber layer is designed to withstand pressure of the transported medium and protect the steel wire from erosion. The outer rubber layer protects the steel wire from damage. The steel wire layer serves as the reinforcing material. The rated working pressure can reach 50 MPa.



Fig 4.12 Water Hose and Fittings

4.8 Fall Arrestor

The core principle of the fall arrestor is to achieve automatic locking through sudden speed changes: when the safety cable connected is being smoothly retracted or extended at a normal speed, the internal centrifugal mechanism remains in a relaxed state. Once a fall occurs causing the cable to be pulled out at an extremely high speed, the centrifugal force drives the swing block to quickly engage the ratchet or friction braking device, instantly locking the cable, and achieving forced braking within 0.2 seconds, limiting the fall distance to be within 0.5 meters. The entire process does not require electricity or manual intervention, and the pure mechanical triggering ensures reliability. The fall arrestor using steel wire ropes is lightweight and easy to use. The effective steel wire length is 30 meters, and the rated working load is 150 kg.



Fig 4.13 Fall Arrestor

4.9 Unloading Device

The unloading device helps the robot to leave the steel surface. The device has a handle and can also be used as an anchor point, and it will not be attracted by the robot magnet since it is made of non-magnetic materials. The device can be placed on any steel surfaces and drive the robot onto its surface to achieve separation between the robot and the working surface.



Fig 4.14 Unloading Device

4.10 Lifting Pulley

The single-wheel lifting pulley is a simple and efficient lifting tool. Its working principle is based on the mechanical properties of the fixed pulley. By changing the direction of the force, it can lift heavy objects. The pulley's wheel is fixed on the support and is used as a fixed pulley. It does not reduce the pulling force, but can change the direction of the force application. By using the pulley, the maneuverability of the robot can be improved, and it can also be used to lower and place items into the hold.



Fig 4.15 Single Wheel Lifting Pulley

4.11 Cargo Lifting Pallet

The lifting pallet is a transfer device designed for short-distance transportation of robots. The bottom of the pallet has universal wheels, suitable for short-distance transportation of robots. Additionally, the pallet is equipped with a lifting ring, which can be used to lift the robot, for example, when lowering the robot from the deck to the cargo hold.

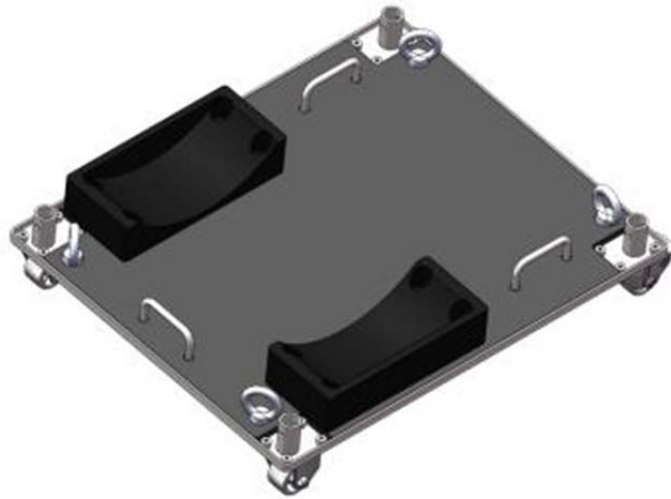


Fig 4.16 Cargo Lifting Pallet

4.12 Toolkit

The tool kit includes all the tools needed for daily maintenance and repair of the entire system. Please store them properly. The list of the tool kit is as follows:

Tool Name	Specifications	Qty.
Toolkit	33 * 21.5 * 25 cm	1
Monkey Wrench	4-inch, 24mm	1
Monkey Wrench	8-inch, 41mm	1
Needle-nose Plier	6-inch	1
Straight Screwdriver	3.2 * 100mm	1
Cross Screwdriver	PH0 * 100mm	1
T-shape Hexagonal Socket Spanner	17 mm	1
Allen Key Set	9-piece-set, 1.5~10 mm, ball head	1
Oil-seal Hook	Bend 135 degrees	1
Circlip Plier	7-inch, straight end, outside	1
Feeler Gauge	SIC210-600.001.A	1
Lifting Pulley	0.5t	1
Teflon Tape	13mm * 15m, white	1
Fuse	RT18-32, 32A	1
Terminal Wire	15cm, I type, XH2.54, red and black	1

4.13 Things to Take Note

The connectors of the electric control system are protected with covers. When the system is not running or in use, please put back the cover to keep any dust or liquid away from entering the system.

Please use the correct connector for connection. The socket has fool-proof design, therefore if obstruction is felt when plugging in, please check the direction of inserting again or check if the correct plug is used.

Nameplates are fixed on the robot, the remote control and the electronic control cabinet. Please keep them clean, with clear and legible text. The diagram of the nameplate is as follows:



Fig 4.17 Nameplates for Robot, Control Cabinet and Remote Control

The serial numbers are all marked on the nameplates. The serial numbers are the key numbers for tracing the detailed production details of the equipment. Please properly record and keep them.

On the key components of the robots, there are part codes. These codes can trace the production details of this part. Please properly record and keep them.

5. Transportation and Storage

5.1 Things to Take Note

The robot is equipped with strong magnets, therefore please ensure to keep the robot away from any non-working metal surfaces. During transportation, prevent any metal objects from being attracted by the magnets, in case any heavy objects are attracted and cause falling and injuries, or sharp items are attracted which will damage the robot and cause injuries.

During manual transportation, at least two workers are required to carry one robot. Single-person carry is strictly prohibited. During the transportation, the two workers should grip the handles respectively, and hold the front connecting rod of the robot to prevent overturning. Workers should also check if they have brought any metal products to avoid attraction by the magnets.

The robot should be placed on magnetic insulation surfaces, and it must not be put on the ground or any other steel surfaces randomly.



Pay attention to the strong magnet!

The robot is equipped with strong magnets, therefore electronic devices such as mobile phones and pacemaker should be kept away.

5.2 Metal Transfer Box

For long distance transportation, it is recommended to use the transportation device for help, as shown by **Fig 5.1**.



Fig 5.1 Metal Transfer Box

The dimension of the transportation device is 1230×750× 1650 mm. The device is multi-functional, can be used for both transportation and storage of the product. The wide space allows the operator to store many other supplementary tools and products, including robot, fall arrestor, control cabinet, power cable, remote control, tool kit, unloading device and other spare parts. It significantly helps to improve the transportation and house-keeping process.

Take note that when using the device, the operator needs to ensure the structure of the transportation device is intact. The device should not be damaged or deformed for safety reasons. When placing other items, make sure they are put safely and properly-fixed, to prevent shaking or falling during transportation. On the other hand, when transporting the device, choose appropriate way to carry it according to the actual total weight so that to avoid injuries or accidents caused by overweight. The relevant should wear proper PPEs and strictly follow the rules.

5.2.1 Short-distance Transportation

When operating with a forklift, precisely insert the forks into the bottom of the device and keep them level while moving slowly. If manual transportation is required, release the brakes of the wheels, push the case to the designated position, and then turn on the

brakes as shown in the figure:



Figure 5.2 Braking position of the universal wheels

Before transportation, double confirmation is required: the door lock is fully closed, and the anti-detachment pin is inserted into the positioning hole, the internal equipment is completely fixed with straps.

In scenarios with uneven roads, rubber shock-absorbing plates should be laid on the transportation path to avoid deformation of the box bottom due to force.

5.2.2 Long-distance Transportation

Before packing, apply temporary anti-rust wax on the outside of the box. Use high-strength binding straps to fix it. The end buckles need to be inserted into the tray grooves to prevent loosening.

5.2.3 Lifting

The transfer box is equipped with lifting rings, and it can be lifted using these rings. Overall reference weight: 500 kg.



Fig 5.3 Lifting Ring Position

5.2.4 Storage

Special attention should be paid to moisture prevention and salt corrosion protection in the ship's environment. The storage area should be kept away from high temperatures, open flames and damp corners. Regularly check if there is any water seepage or condensation in the box. Check the straps for looseness every week and the rainproof fabric for damage. Inspect the equipment surface for rust or salt crystal residue every month and deal with it promptly. During typhoons or bad weather conditions, additional reinforcement of the straps is required and the inspection frequency should be increased.

5.3 Plastic Transfer Box

The dimensions of the plastic transfer box are $800 \times 600 \times 1800$ mm. This transfer box has multiple functions and can be used for storing and transporting equipment. Its interior space is spacious, and it adopts a one-piece structure made of high-strength engineering plastic. The surface is treated with UV resistance, and has an IP67 protection level. The inner wall is covered with a customized EVA cushioning filling layer, providing shock absorption, moisture protection, and anti-static protection. It can accommodate core equipment components such as robots, fall arrestors, electrical control cabinet, cables, and remote controls. The internal layout of the box is flexible, and it can also hold tool kits, off-the-workstation items, spare parts, etc. Combined with the anti-collision guard angle design at the four corners, it provides great convenience and security for the organization, storage, and transfer of equipment.

Specifically for marine usage scenarios, the joint areas of the box are designed with double-layer sealing rubber strips, and the locking mechanism structure can effectively resist humid and salt-spray environments. Additional anti-slip rubber pads and fixed anchor points are added at the bottom to meet the requirements of bundling and fixation on decks or cabins.

It should be noted that when using the plastic transfer box, ensure that the box body has no cracks, and the joints are not cracked. Avoid long-term exposure to sunlight and seawater immersion, as this can cause material aging. When placing equipment and items, use the partitioned fitting characteristics of the EVA filling layer and the built-in binding device to place and fix them properly to prevent damage to the equipment or items from shaking or collision during transportation. During the transfer process of the transfer box, use the embedded forklift slot at the bottom or the side grip design of the box. Select appropriate handling tools and methods based on the actual weight to avoid falling due to the smooth surface of the box. During marine operations, it is recommended to regularly rinse the box surface with fresh water to remove salt deposits and check the integrity of the sealing rubber strips.



Fig 5.4 Plastic Transfer Box

5.3.1 Short-distance Transportation

Use the handles of the box for transportation. When transporting on a slope, adopt a "Z" shape route to reduce the risk of center of gravity deviation. When transporting multiple boxes together, you can temporarily combine the side concave-convex interlocking structure of the box to form a unit module to improve the transportation efficiency. When operating with a pallet truck or battery-powered forklift, adjust the width of the forks to match the guide rails of the box bottom forklift slot.

Reference weight of a single box: 80 kg



Fig 5.5 Plastic Transfer Box Short Distance Transportation

5.3.2 Long Distance Transportation

During shipping, the containers need to be arranged longitudinally inside the container, and the bottom anchor points should be connected and fixed to the D-ring of the container with straps. Anti-slip pads should be placed between the layers. During land transportation, the containers should be at least 10 cm away from the side walls of the freight compartment to avoid friction and scraping.

5.3.3 Lifting

The transfer boxes are all equipped with lifting rings. Individual box can be lifted using the lifting ring directly. For multiple boxes, a high-strength lifting strap is used to bind the transfer boxes together, and then carry out the lifting.

Overall reference weight: 270 kg



Fig 5.6 Plastic Transfer Box Lifting

5.3.4 Storage

It is recommended to place drying agent in the box to prevent the equipment from being corroded by humid air. After all items are loaded, select a flat and ventilated storage area on the ship, and use straps and metal snap rings to firmly fix the transfer box to avoid displacement caused by vibrations. The outside of the box needs to be covered

with a rain cover and tied tightly with ropes to prevent seawater from splashing in or rain from seeping in.

Special attention should be paid to moisture prevention and salt corrosion on the ship. The storage area should be far away from high temperatures, open flames and damp corners. Regularly check if there is any water leakage or condensation in the box. Check if the straps are loose and if the rain cover is damaged every week. Open the box monthly to check if there are any rust marks or salt crystals remaining on the equipment surface, and handle them in time. During typhoons or bad weather, additional reinforcement of the straps is required and the inspection frequency should be increased.



Fig 5.7 Robot Package in the Plastic Transfer Box

5.4 Robot

5.4.1 Short Distance Transportation

Before handling, the operators must wear anti-slip protective gloves and safety shoes, and check the structural integrity of the dedicated handles on both sides of the robot. At the same time, the working area must be cleared to ensure an unobstructed space of at least 2 meters. At least 2 operators is needed to carry the robot. It is recommended that the height difference between the operators be controlled within 15 cm, and adopt the standard grip posture with the palm facing upwards to hold the handles.

Special attention should be paid to magnetic protection. It is required that the robot body maintain a safe distance of at least 30 cm from metal objects. In particular, pay attention to metal items carried by the operators, such as keys, tools, and watches. For personnel with medical implants such as pacemakers, a separation distance of at least 2 meters must be maintained. When lowering the equipment, it should be done at a uniform and slow speed to ensure that the robot makes a smooth contact and slowly detaches from the pallet, and it is strictly prohibited to tilt more than 15° on one side.



Fig 5.8 Robot Handles and Contact Points

5.4.2 Long Distance Transportation

For long-distance transportation, please use transfer boxes. Before packing, use soft brushes and neutral cleaners to remove salt deposits, oil stains, and other residues. Avoid using irritating solvents for plastic components.

5.4.3 Lifting

The lifting ring / hook adopts a universal rotating mechanical structure, allowing for free adjustment of the lifting angle of 360° . This effectively avoids the stress concentration caused by angle deviations. Before conducting the lifting operation, a double check must be carried out. Firstly, functional tests should be conducted on the lifting ring to confirm that the rotating mechanism operates smoothly without any jamming, and torque wrenches should be used for secondary tightening of the connecting threads to ensure that the pre-tightening force meets the design standards. Secondly, when installing the matching lifting hooks, it is necessary to carefully check whether the double-locking mechanism of the safety lock device is fully engaged. This should be verified through visual inspection and mechanical testing to ensure its locking reliability. During the lifting, operators should maintain a stable lifting speed of 0.5 to 1 m/s, and strictly implementing safety distance management to ensure that the lifted equipment maintains a distance of at least 1.5 times the equipment height from surrounding metal components, pipelines, and other hard objects. In addition, it is recommended to set up safety warning signs in the operation area, and implement full-process monitoring through a two-way communication system between ground supervisors and crane operators to minimize the risk of collisions.



Fig 5.9 Lifting Ring of the Robot

5.4.4 Storage

After using the equipment, it is necessary to thoroughly clean the surface stains first. Use a soft brush and neutral cleaner to remove salt deposits, oil stains, and other residues. Avoid using irritating solvents on plastic parts. The cleaned equipment should be completely dried before being neatly placed in the transport box.

5.5 High Pressure Pump

5.5.1 Short Distance Transportation

The high-pressure cleaning machine is equipped with universal wheels, which facilitate short-distance transportation. During the transfer process, it is necessary to be cautious of any obstacles on the ground to prevent damage to the equipment. If it is necessary to pass over a large slope, do not attempt manual transportation to avoid personal injury.

5.5.2 Long Distance Transportation

Before packing, apply temporary anti-rust wax on the outside of the box. Use high-strength binding straps to fix it in a # shape. The end buckles need to be inserted into the tray groove to prevent loosening. When operating with a forklift, precisely insert the forks into the bottom of the box, keep the forks level and move them slowly and smoothly. The position is as shown in the figure:



Fig 5.10 High Pressure Pump Long Distance Transportation Guide

5.5.3 Lifting

The installation of the high-pressure cleaning machine requires the use of high-strength lifting belts. Please position the lifting belts according to the figure below and firmly tighten them before proceeding with the lifting operation.

Reference weight: 520 kg



Fig 5.11 High Pressure Pump Lifting Position

5.5.4 Storage

Storage of the high-pressure pump should be carried out as follows:

- 1) Turn off the pump and the water supply.
- 2) Release the residual pressure until no water flows from the nozzle.
- 3) Lock the trigger and pull out the power plug.
- 4) In winter, after using the pump to draw in non-corrosive and non-toxic anti-icing fluid, store it. Handle it according to the following steps:

- (1) Remove the water inlet hose and the high-pressure outlet hose
- (2) Start the machine and run for 30 seconds to discharge the water in the pump.
- (3) Blow out the residual water in the high-pressure hose with an air pump.
- (4) Fill it with anti-freezing fluid.

After completing these steps, thoroughly clean the surface. Use a soft brush and a neutral cleaner to remove salt and oil stains, etc. Avoid using irritating solvents on plastic parts. The cleaned equipment needs to be completely dry before being placed in a flat and ventilated storage area. Use straps and metal snap rings to firmly fix it. Cover with a rain cover and tie it tightly with ropes to prevent seawater from splashing in or rainwater from seeping in.

6. Operation Procedure



Please read and fully understand the following content before operation!

6.1 Water and Power Supply Instruction

To better use our equipment, please read the following content to check whether the parameters meet the requirements and whether the connectors and relevant dimensions are suitable. If they do not meet our needs, please identify the items that cannot satisfy the requirement and provide the existing parameters. We will then proceed to make adaptive modifications or prepare new parts as necessary to ensure the smooth operation of our cargo hold cleaning robot system.

6.1.1 Water Supply

The water supply must use freshwater, with the source positioned no more than 20 meters from the cargo hold (hatch coaming edge) to be cleaned, and must comply with the following specifications:

Pressure	>0.5 MPa
Flow Rate	>30 L/min
Particle Size	<40 μm

We will provide the following two types of water supply couplings / connectors as shown below. The adapter maybe removed for straight piping connection to 1" (25 mm) ID hoses.



Fig 6.1 Water Supply Connectors

6.1.2 Pump AC Power Supply – 440V

The power supply must be located within 50 meters of the cargo hold (hatch coaming edge) requiring cleaning, and meet the following electrical requirements:

Voltage	AC 440 V, 60 Hz
Current	>63 A

We provide the following plug. If the plug is not suitable, the connector can be removed for direct wiring connection.



Fig 6.2 Industrial Power Plug for 440VAC

6.1.3 Robot AC Power Supply – 220V

The power supply must be located within 15 meters of the cargo hold (hatch coaming edge) requiring cleaning, and meet the following electrical requirements:

Voltage	AC 100 – 240V, 50/60 Hz
Current	≥ 10 A

We provide the following adapters. If incompatible, the connector can be removed for direct wiring termination.



Fig 6.3 Power Plugs for Robot

6.2 Deployment

The system deployment diagram is shown as follows:

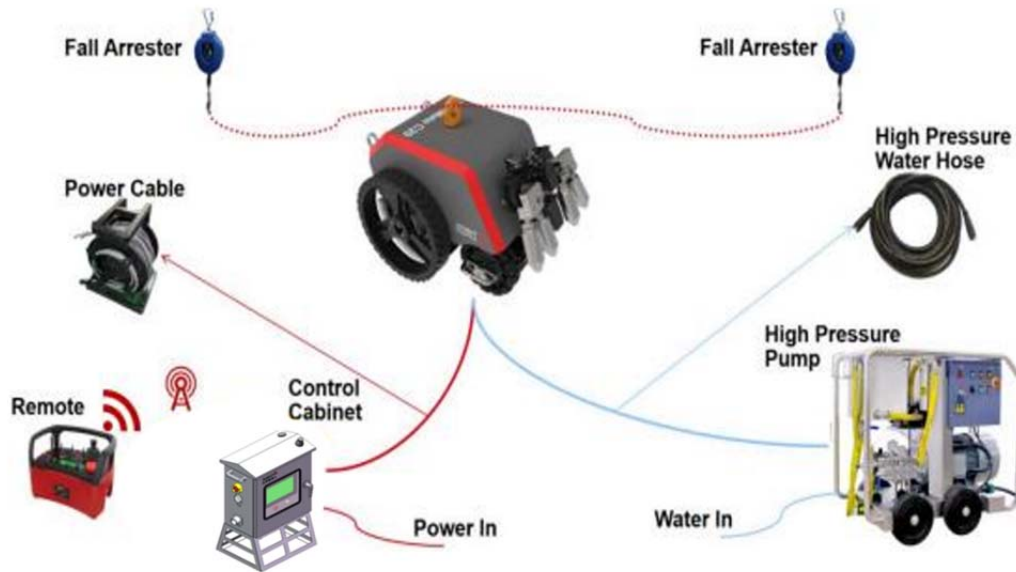


Fig 6.4 Robot System Deployment

The deployment procedures are listed below, please follow this step by step for a safe operation process:

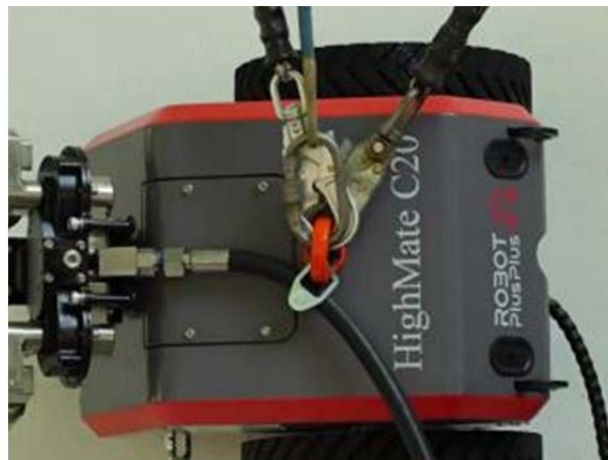
- 1) Before starting to use the robot, please first suspend the pair of fall arrestors that at a high position (around the hatch coaming). Ensure that the hanging points are firm and the connections are reliable. The suspension positions of the two fall arrestors should be in the same plane as the working surface.



- 2) Connect the hook of the fall arrestors with the lifting ring of the robot and make sure it is firmly locked.

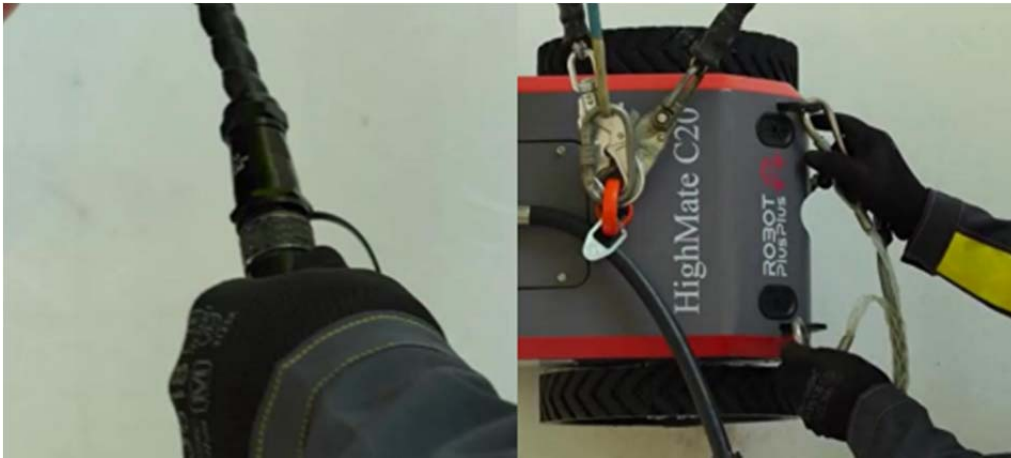


- 3) Attach the safety rope hooks onto the robot.



- 4) Connect the blue aviation plug of the power supply cable with the control cabinet.
Note the protrusion of the plug and insert the plug firmly.
- 5) Connect the black aviation plug from the cable reel to the control cabinet. Pay attention to match the red dots on both the plug and the socket to insert the plug correctly.

- 6) Connect the black aviation plug from the cable reel to the robot. Pay attention to match the red dots on both plugs to insert the plug correctly. Put on the anti-burst protection casing on the water hose.



- 7) Connect the high pressure hose with the robot and tighten with spanner, secure the protection casing hook.



- 8) Connect the other end of the high pressure hose with the high pressure pump. Tighten with spanner.

- 9) Release the emergency stop button, the red indicator light should turn on which indicates successful power supply. (If the equipment is used for the first time, open the top cover and close the air circuit breaker and closer the cover. For subsequent operations, repeat this process every month)
- 10) Reset all the keys and knobs back to zero on the remote control, release the emergency stop button.



- 11) Press the green button on the side of the remote control, wait for the green indicator light and screen to light up which indicates the power on of the remote.



- 12) After successful connection between the remote and the cabinet, the red indicator light will stop blinking, and the error code shown should be blank.



- 13) Push the power button up to enable the robot control, rotate the red knob for adjusting the speed which will be shown on the remote screen.



- 14) Now the robot has been successfully deployed and powered, the operator can turn on the high pressure pump and start operation.

6.3 Remote Control Instruction

6.3.1 Key Instruction

The remote control has many buttons, keys and knobs. The detailed descriptions of them are listed below

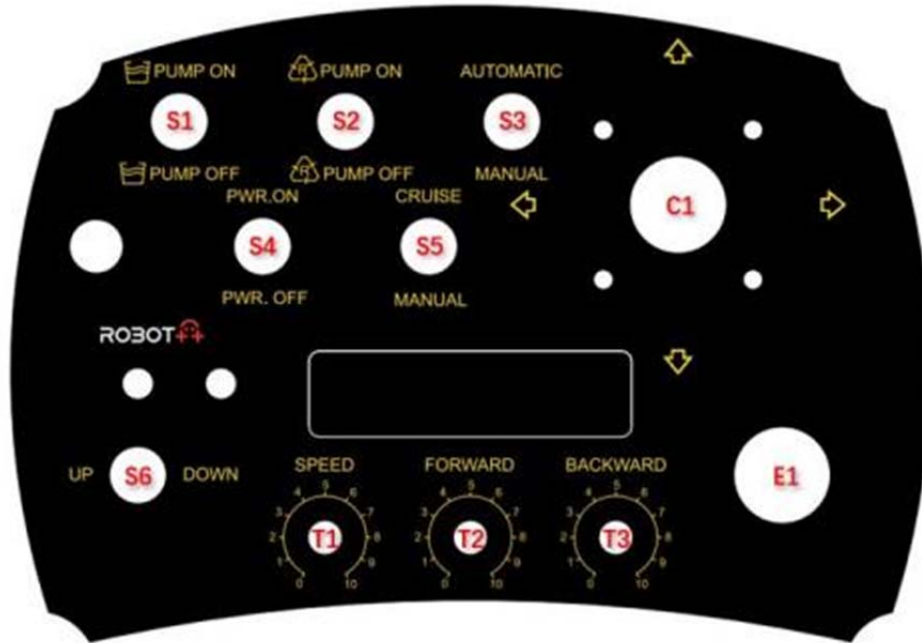


Fig 6.5 Remote Control Panel



Fig 6.6 Side View of the Remote Control

Key / Button	Description
E1	Emergency stop button
C1	Robot control joystick. The joystick can achieve robot motion in 4 directions, which are forward, backward, left turn and right turn respectively
S1	Pump switch. Upward is pump-on, and downward is pump-off.
S2	Electric rotation nozzle automatic mode switch. Push up to turn on the function, and downward to off it.

S3	Auto mode switch. Upward is auto-navigation mode, downward is manual mode.
S4	Robot system switch. Upward is power on, downward is power off.
S5	Cruise mode switch. Upward is cruise mode on, downward is cruise mode off.
S6	Rotation nozzle switch. Left side is lifting, right side is lowering, and middle is keeping the position unchanged. Extension arm switch. Left side for lowering and right side for lifting, middle to keep the position.
S10	Lane change distance increases by 10 mm.
S11	Reserved key. No actual use.
S12	Lane change distance decreases by 10 mm.
S13	Reserved key. No actual use.
S14	Green power button. Long press until screen lights up to power on the remote control.
T1	Speed control knob. The adjustable range is 0 – 25 m/min, rotate to adjust.
T2	Forward mileage knob. The adjustable range is 0 – 20 m, rotate to adjust.
T3	Backward mileage knob. The adjustable range is 0 – 20 m, rotate to adjust.



Start and stop the equipment rapidly is strictly prohibited. This may cause program malfunctions and lead to uncontrollable risks.



Auto-navigation has a higher priority than cruise mode. When both auto mode and cruise mode are activated, the robot operates auto mode.

The remote control comes with 2 lithium batteries, each of which can provide 24 hours of power for the remote control. In case of special circumstances or force majeure, emergency/temporary batteries can be used.

The terminal cable (15cm, I type, XH2.54 wiring, red and black) is included and placed in the tool kit. The terminal cable can be plugged into the position of the remote control battery, and then a 9V battery can be connected.



Fig 6.7 9V Battery Sample

6.3.2 Display Screen

MODE: MANUAL	VOLT: 6.6 V
SPD: 2.54 m/min	LANE.DIS: 0.8 m
FWD.MLG: 5.3 m	BWD.MLG: 6.1 m
RT.MLG: 1.2 m	ERROR: 0xf007

Fig 6.8 Display Screen

Display Item	Description
MODE	Mode, shows the current operation mode of the robot, and it has auto-navigation, cruise mode and manual mode
VOLT	Voltage, shows the current voltage of the remote control which reflects the battery left
SPD	Speed, shows the current moving speed of the robot.
LANE.DIS	Lane changing distance, shows the distance of the automatic lane changing under auto mode
FWD.MLG	Forward mileage, shows the forward mileage under auto mode
BWD.MLG	Backward mileage, shows the backward mileage under auto mode
RT.MLG	Real time mileage. Shows the real time mileage recorded, reset to zero every time when re-starting the remote control
ERROR	When robot is not working normally, certain error code will be shown on the screen

6.4 Control Cabinet Instruction

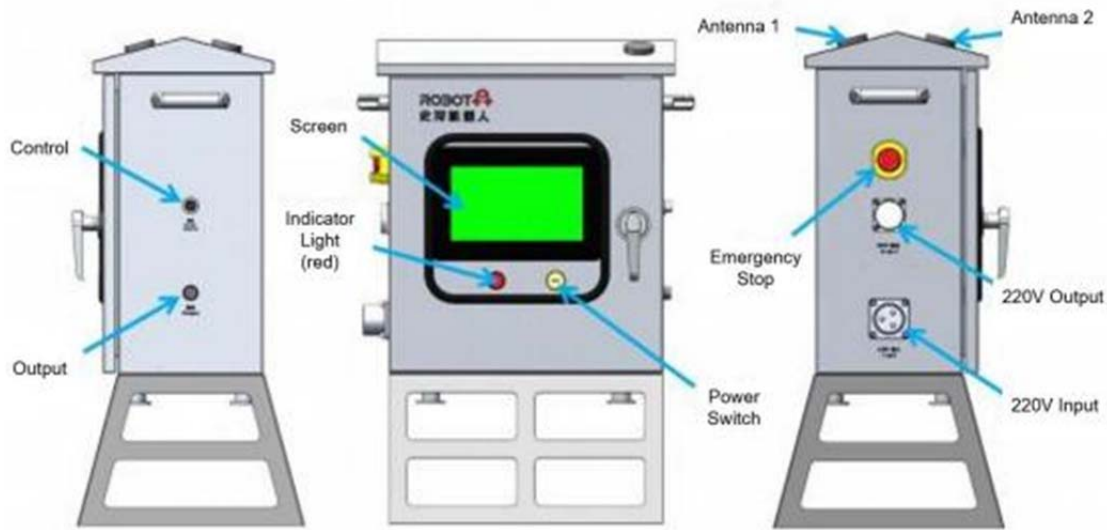


Fig 6.9 Control Cabinet Structure

Please refer to the table below for the instructions of all the indicator lights, buttons and connectors of the control cabinet.

Control interface: control the spot blasting valve and UHP pump

- Output interface: power supply between the cabinet and the robot
- 220V Input interface: power input of the 220V AC
- 220V Output interface: 220V AC socket
- Emergency stop button: used for emergency stop, cut-off the power of robot immediately
- Antenna 1: DTU antenna, 2.4G
- Antenna 2: remote control antenna, 433 MHz frequency.
- Indicator light – red: when it is on or blinking, it means that there is an error or the emergency stop button is not released
- Switch: control the power of the cabinet
- Screen: after the power is turned on, a logo will be shown. When the robot is operating, the screen will show the specifications include total time, error code, moving speed, loading percentage, version number,

lane changing distance and current operation method

- RF specifications

Parameter	Specification
Wireless Module Model	E22-900T30S
Ant	Cabinet antenna,5dBi
Crystal Frequency	32 MHz
Operation Frequency Band	903 MHz – 927 MHz
Modulation Type	LoRa

6.5 Cleaning Module Instruction

There are 3 different modules used for the cleaning operation, which are fixed nozzle module, electric rotation nozzle module and extension arm module. Usually, the fixed nozzle module can be used for cleaning ship hulls, cargo hold main areas and other large flat surfaces. Electric rotation nozzle can be used for cleaning hold shell frames, corrugated walls and other complicated areas, and also can be used on large flat surfaces. The extension arm module can be used for cleaning those areas that cannot be reached by the robot, like ladders, steps, pipelines, etc.

6.5.1 Fixed Nozzle Module

The fixed nozzle angle is not adjustable. Connect the high pressure hose and start operation.

6.5.2 Electric Rotation Nozzle

The electric rotation nozzle and swing in the horizontal direction, and it can also swing during the cleaning process. Use the key on the remote to adjust the nozzle angle as shown:



Fig 6.10 Electric Nozzle Automatic Key

Push S2 key upward to enable the automatic swinging of the rotation nozzle. When it reaches the maximum position, it will swing back and repeat this process, until the user turn off the function by pushing down the key which will stop the swinging.



Fig 6.11 Electric Nozzle Manual Key

The rotation nozzle can be adjusted manually as well.

- 1) S2 needs to be under MANUAL mode.
- 2) Move switch S6 to the upward position on the left. The nozzle starts to rotate upwards. When it reaches the maximum position, the nozzle will stop moving.
- 3) Move switch S6 to the downward position on the right. The nozzle starts to rotate downwards. When it reaches the maximum position, the nozzle will stop moving.
- 4) When the nozzle reaches the required position, move switch S6 to the middle position. The nozzle will stop rotating.

By rotating the nozzle to different positions, it can be used to clean different areas, as shown in the figure below:

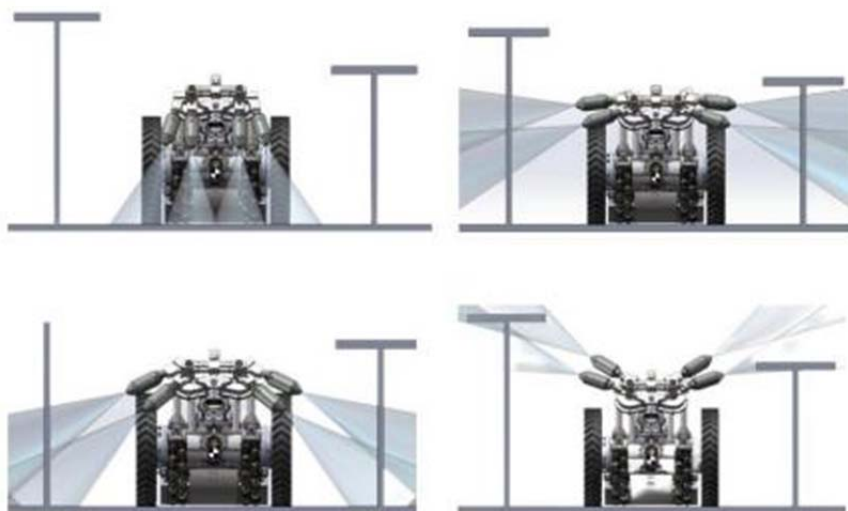


Fig 6.12 Area of Cleaning by Adjusting the Rotation Nozzle

The cleaning areas of this module includes, but not limited to these positions. Additionally, the following positions can also be cleaned as shown in the figure:



Fig 6.13 Cleaning Scenario

6.5.3 Extension Arm Module

The arm on the extension arm module has multiple adjustable degrees of freedom. The arm is composed of 4 independent arms, as shown in the figure below.

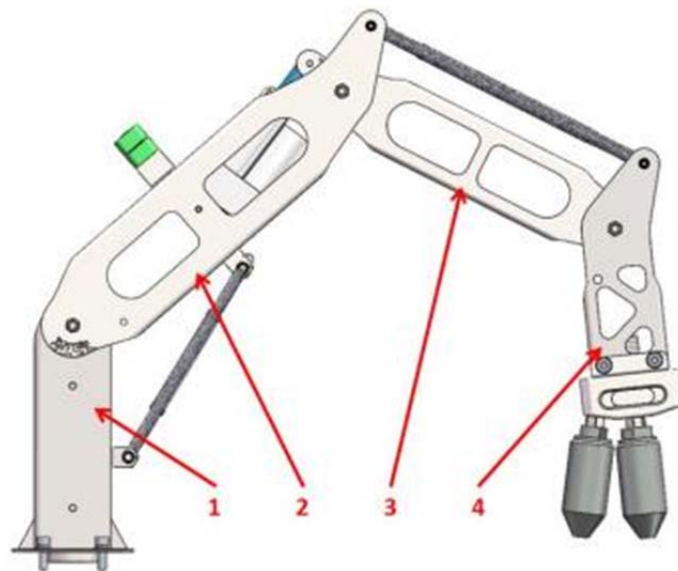


Fig 6.14 Arm Numbers of the Extension Arm Module

The angle between the two adjacent arms can be adjusted. The adjustable angle is shown in the following figure:

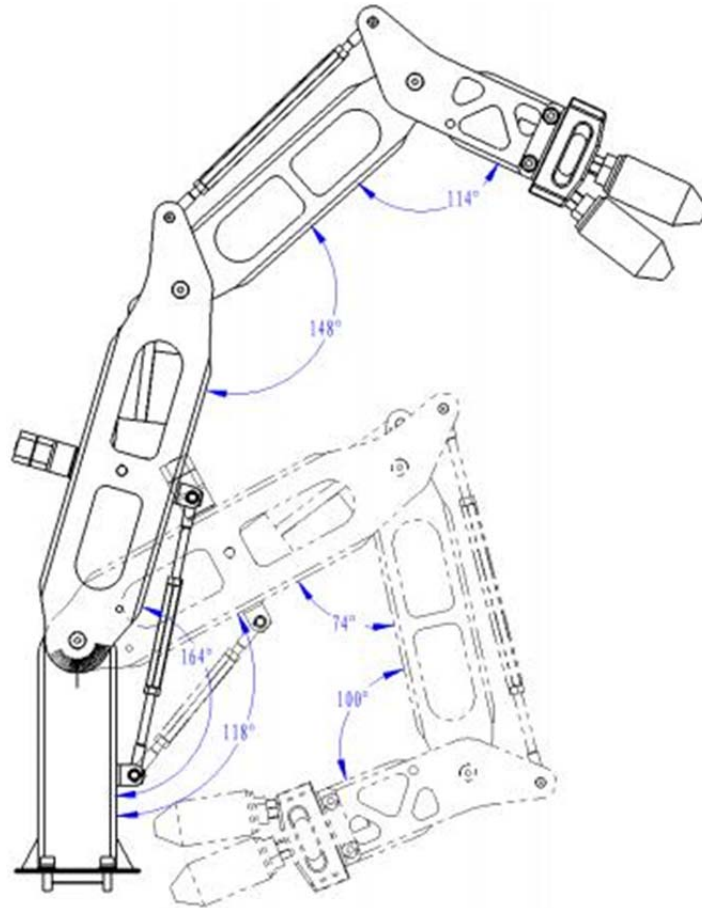


Fig 6.15 Adjustable Range of the Arms

The range is also shown by the following table:

Arm No.	Min. Angle	Max. Angle	Range
Arm 1-2	118°	164°	46°
Arm 2-3	74°	148°	74°
Arm 3-4	100°	114°	14°

Among them, the angle between arm 2 and arm 3 can be adjusted electrically. The angles between the other arms need to be manually adjusted using tools.

The adjustment method for arm 1-2 is as follows:

- 1) Use a 13mm open-end wrench or adjustable wrench to loosen nut 1
- 2) Use a 13mm open-end wrench or adjustable wrench to rotate rod 2
- 3) Continuously rotate rod 2 to adjust the angle between arm 1 and arm 2
- 4) Tighten nut 1 to complete the adjustment

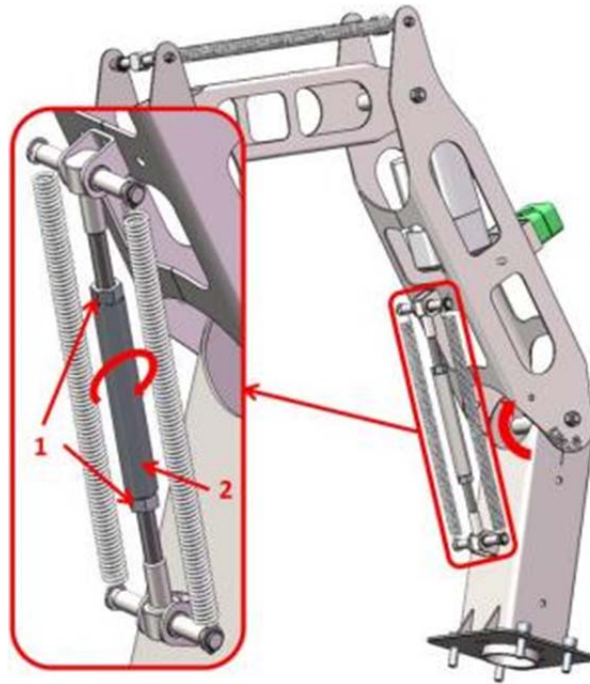


Fig 6.16 Arm 1-2 Adjustment

The adjustment method for arm 3-4 is as follows:

- 1) Use a 13mm open-end wrench or adjustable wrench to loosen nut 1
- 2) Use a 13mm open-end wrench or adjustable wrench to rotate rod 2
- 3) Continuously rotate rod 2 to adjust the angle between arm 3 and arm 4
- 4) Tighten nut 1 to complete the adjustment

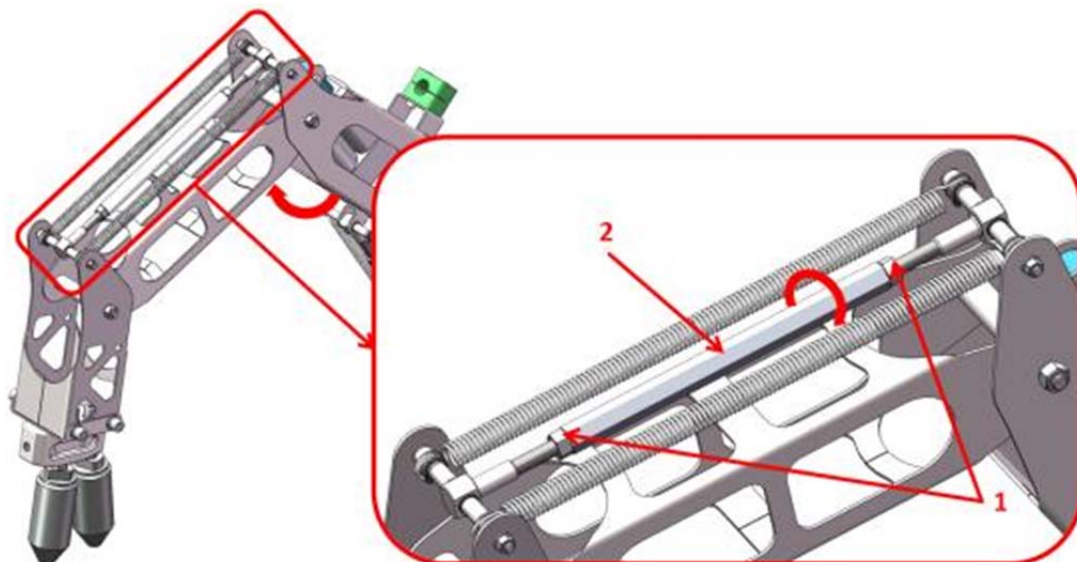


Fig 6.17 Arm 3-4 Adjustment

The adjustment method for arm 2-3 is as follows:



Fig 6.18 Switch Position

- 1) Move switch S6 to the upward position on the left. The arm starts to rotate upwards. When it reaches the maximum position, the arm will stop moving.
- 2) Move switch S6 to the downward position on the right. The arm starts to rotate downwards. When it reaches the maximum position, the arm will stop moving.
- 3) When the nozzle reaches the required position, move switch S6 to the middle position. The arm will stop rotating.

The arm can be used for cleaning different areas when it reaches different positions as shown:

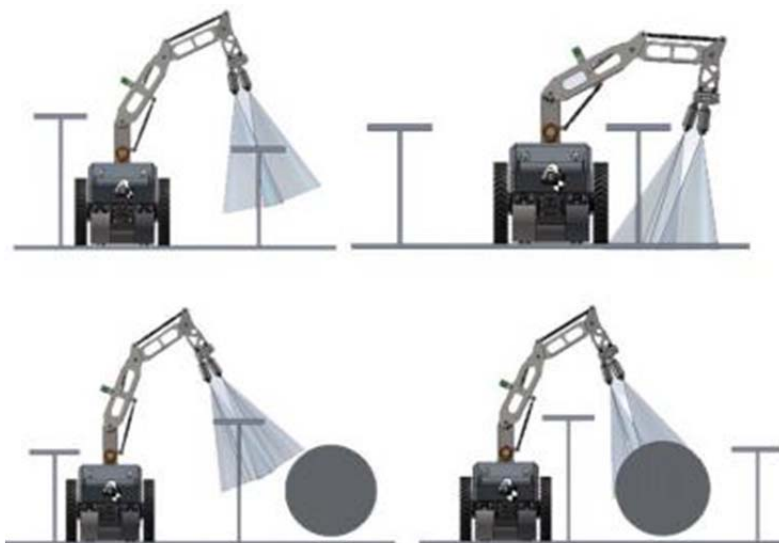


Fig 6.19 Cleaning Areas of the Extension Arm Module

The cleaning area of the extension arm includes but not limited to these areas, it can be used for cleaning the following area as shown:



Fig 6.20 Cleaning Areas of the Arm Module

6.5.4 Instructions of the Nozzle Only

When only using the nozzle as the cleaning tool separately, follow these instructions below:



Make sure the rotor can rotate freely in the nozzle.

- 1) Please lock the nozzle shell and the threaded base, and also lock the threaded base to the water hose / water gun.
- 2) Please position the nozzle downward, start the high-pressure pump, and ensure that there is no water leakage from the nozzle after it is turned on. Only when there is no water leakage can you orient the nozzle in any direction.
- 3) Please keep the nozzle 20 to 30 cm away from the object to be cleaned. During the cleaning process, adjust the distance as needed to achieve the best efficiency and results.



Fig 6.21 Nozzle Operation

Notes: If any of the following situations occur, please immediately stop using it:

- 1) The rotation speed of the rotor is not stable or fluctuates.
- 2) Strong vibration is noticed from the nozzle.
- 3) Water jet from the nozzle does not form a cone shape.

After changing necessary parts or consumables, if the above problems are still not solved, please contact the nozzle manufacturer.

6.6 Instructions of the High Pressure Pump

6.6.1 Safety Instructions

For safe use of the equipment, please read the following contents carefully:

- 1) To prevent accidents and ensure the safety of operators, bystanders, and surrounding machinery, some warning signs or safety precautions should be placed nearby. Treat the machine as a high-speed cutting tool.
- 2) Do not allow children, individuals with behavioral disorders, or those who have not read the safety operation manual to operate the machine.
- 3) Do not use flammable and highly toxic solutions or other flammable and explosive liquids as cleaning agents.
- 4) Do not use the cleaning machine outdoors when it is raining, do not touch the plug or socket with wet hands, and do not use the cleaning machine when the power cable is damaged as there is a risk of electric shock.
- 5) The high pressure pump must be connected to a power source with a ground wire, to avoid electric shock hazard. Using a safety current circuit breaker will provide additional protection for the operator.
- 6) Installation of the power source and related works must be operated by a professional electrician.
- 7) To protect the safety of the cleaning workers, check the accessories before use, and verify the insulation condition of the machine's wiring. If you find any problems, do not start the machine and carry out maintenance.
- 8) When using the cleaning equipment and its accessories, pay attention to protecting the eyes. Otherwise, splashing substances can cause harm.
- 9) When using the equipment, avoid endangering the operators. PPEs must be worn. Do not aim the high-pressure gun at anyone including the operator himself. Do not use high-pressure water to clean clothes or shoes.
- 10) A safe distance must be kept for the bystanders from the working area to prevent accidents.
- 11) Do not spray water on electrical instruments or machines themselves.

- 12) When repairing or maintaining the equipment and replacing accessories, make sure the machine has been turned off, and the wires need to be separated from the power source.



This machine is only for use within the design scope. Any other usage will be regarded as inappropriate and potentially dangerous. The manufacturer will not be held responsible for any inappropriate or dangerous operations.

6.6.2 Instructions During Operations

To use the equipment safely and in compliance with related rules and regulations, please read the following guides carefully:

- 1) Before starting the pump, make sure the water source is turned on and water is flowing. Operating the equipment without water will damage the water seal.
- 2) Do not unplug by pulling the wire.
- 3) If the operator is far away from the object to be cleaned, do not move the pump by pulling the high-pressure hose or power cable.
- 4) Prevent the pump from freezing in winter.
- 5) Do not adjust the water flow angle while the machine is running.
- 6) Use the cleaning machine in case of damage to the high-pressure hose.
- 7) The pump can only use accessories and parts authorized by the manufacturer. Original accessories and parts can provide safe and trouble-free operation.
- 8) Do not modify or change the parameters of the safety valve. It poses an explosion hazard.
- 9) Do not fix the trigger in the operating position. (for using dump guns)
- 10) Check if the parameter label is fixed on the equipment. If not, notify the dealer. Do not use equipment without a label, they have not been identified and may pose potential dangers and accident risks.
- 11) Do not leave the pump unattended.
- 12) All power contacts must be waterproof.

- 13) Before doing any work on the pump, unplug the plug to prevent the risk of accidental startup.
- 14) Confirm with the local water supply company. According to the DIN 1988 standard, if a check valve is installed in the water supply pipeline, the pump must be installed on the main water pipeline.
- 15) The maintenance and repair of electrical components must be carried out by professional personnel to avoid accident risks.
- 16) Before disconnecting the hose, the pressure must be released to avoid injury risks.
- 17) Before each use of the pump, check if it is firmly installed and there are no damaged components to avoid accident risks.
- 18) Only cleaning agents that do not cause harm to the high-pressure hose and the power cable can be used.

6.6.3 Operation Instruction

6.6.3.1 Before power on

- 1) Connect the water source to the pump inlet.
- 2) Connect the high pressure hose to the pump (it's better to keep at least 3 meters of hoses at the same height as the water outlet, a rope can be used to hold it).
- 3) Connect the hoses to the manual gun / robot. Turn on the main switch, release the emergency stop, and rotate the pump switch from OFF to ON position. Observe the direction of the pump rotation which is labeled by an arrow.
- 4) Confirm the pump is running in the correct direction. If the direction is correct, observe if the pressure gauge is pointing at 4.5 bar, if the pressure does not reach 4.5 bars, run the pump for 1 minute and repeat 3 times. If the pressure still cannot reach 4.5 bar, the pump needs to be drained.
- 5) Loosen the small nut at the inner side of the pump. Use a 12-inch wrench to loosen it slightly, do not loosen it too much. Once the pressure is normal, the user can proceed to the next step.

6.6.3.2 Power on



High-pressure water can be dangerous. Pay extra attention to safety when operating.

Press the START button, and the pump will be started. After 10 seconds, press the trigger switch of the dump gun or move the robot. (Before the pump starts, the bypass valve must be in the overflow state. Do not press the trigger first. Wait for the pump to run for 10 seconds before pressing the trigger.)



High-pressure hose must not be twisted and must not make small-radius turns during operation.

6.6.3.3 Power off

After releasing the trigger of the gun, (the machine can stop only when the gun handle is in the overflow state), press the STOP button. The pump will gradually stop. After 15 seconds, turn the switch to the OFF position and the pump will stop working. (Note that the large motor can only stop slowly. Before it stops completely, the water supply needs to keep running)

After each time stopping the high-pressure operation and turning off the pump, please release the system pressure. If accessories such as the water hose, high-pressure hose or gun need to be removed, be sure to clean the connection joints thoroughly and then seal them with a clean plastic sheet/bag to prevent foreign objects such as sand and stones from entering and damaging the pump, gun and robot during the next operation.

6.7 Operation Procedures

The detailed operation process will be presented in a video format, providing a comprehensive and clear demonstration of the specific steps and procedures of the robot from unpacking to its official operation. At the same time, in order to better master the relevant operations and functions, please watch and learn the video teaching content multiple times and carefully, and study the application and implementation of related functions for a professional and efficient operation.

6.7.1 Inspection Before Operation

Before operation, the requirements listed below should be carefully followed:

- 1) Make sure all relevant operators are trained properly, and strictly follow the local rules and regulations to proceed to any installments or operation.
- 2) After unpacking, make sure the robot is free from damages.
- 3) Make sure the environment satisfies the requirement listed in section **2.4 Technical Specifications** of this manual.
- 4) Make sure there is no equipment or materials that can be attracted by the strong magnet within the 0.5 meter's range of the robot.



Pay attention to the strong magnet!

The robot is equipped with strong magnets, therefore electronic devices such as mobile phones and pacemaker should be kept away.

6.7.2 Power On and Self-check

- 1) After connecting the power cable, if the remote control signal connects normally then the power supply connection is complete.



The power supply voltage is 220VAC, therefore touching the metal pin on the plug by hand is strictly prohibited.

- 2) Make sure all switches of the remote are power off.
- 3) Turn on the remote control, wait for the indicator light to turn green, then the remote

connection is complete between the control and the robot.



Check the battery voltage of the remote control. If the voltage is less than 7.2V, off the remote and change the battery.

- 4) Move the robot in different directions (forward, backward, left, right), observe if the robot correctly follows the operation order.
- 5) Turn the push rod direction to lifting position and start the brush motor. Observe the rotation of the brush and check if there is any abnormal sound, if not, turn it off.
- 6) Self-check complete.

6.7.3 Procedures Before Operation

- 1) Select the target surface to be cleaned.
- 2) Make sure the robot magnets are free of foreign bodies, if there are please clean them thoroughly.



Pay attention to the strong magnet!

The robot is equipped with strong magnets, therefore electronic devices such as mobile phones and pacemaker should be kept away.

- 3) Connect the power cable and repeat the self-check steps.



The power supply voltage is 220VAC, therefore touching the metal pin on the plug by hand is strictly prohibited.

- 4) Preparation complete.

6.7.4 Operation Procedures



Please wear protection suits, safety shoes, goggles and earplug/muffs during operation.

- 1) After completing section **6.7.3 Procedures Before Operation**, hang the fall arrestors at height to prevent robot from damages in case of accidental falling.
- 2) Drive the robot to the designated area.
- 3) Operate the robot on target surfaces, and the robot should be driven in an 'N' shape back and forth. During operation, pay attention to the power cable for dragging to avoid falling of robot due to cables pulling.
- 4) Start the operation.



It is strongly recommended to test for cleaning a distance before the operation to help to set the appropriate speed.

The effect of cleaning is largely influenced by the type of the stain, type of the coating, ambient humidity and other factors.

6.7.5 Procedures After Operation

- 1) Drive and stop the robot onto the unloading tool. Disconnect the power cable and store it.
- 2) Remove the robot from the steel surface and store.



When taking down the robot, please use the unloading tool.

- 3) Turn off the remote control and store it, keep it sealed.

7. Repair and Maintenance

7.1 Maintenance

7.1.1 Robot

Please check the following content of the robot according to the table below.

Frequency	Content
Real-time	Observe and check the nozzle status of the
Every shift	- Check the preload of all fasteners. - Check the electric connectors have stains or other pollutants.
Every month	Robot complete inspection and cleaning.

7.1.2 Remote Control

During the operation, check the voltage which reflects the battery left of the remote control. A fully charged battery can last for 24 hours. The rated voltage of the battery is 8.4 V, when the voltage is lower that 6.6 V, the battery needs to be replaced or charged.

MODE: MANUAL	VOLT: 6.6 V
SPD: 2.54 m/min	LANE.DIS: 0.8 m
FWD.MLG: 5.3 m	BWD.MLG: 6.1 m
RT.MLG: 1.2 m	ERROR: 0xf007

Fig 7.1 Remote Voltage Display

When the voltage of the battery is low, the green light on the remote will blink.



Fig 7.2 Green Indicator Light for Battery

7.1.3 Control Cabinet

Every month, the air circuit breaker needs to be checked for its working status, especially if the spring can work properly. The procedure is as follows:

- 1) Open the top cover of the cabinet
- 2) Cut off the circuit breaker, wait for 5 seconds, and close the switch
- 3) Close the top cover



Fig 7.3 Air Breaker Check

At the same time, after every operation, check if the cabinet shell is damaged. After cleaning the cabinet, open the top cover in a dry area to check if any water has entered the cabinet. If there are any water or water mark found inside the cabinet, do not use again and contact the after sales.

7.1.4 High Pressure Pump

- 1) Clean the pump filter.
- 2) Check the oil level of the pump.
- 3) Check if the connection point of the high pressure water is damaged.
- 4) Check if the high pressure hose is damaged.
- 5) Check if the power cable is damaged.



Before carrying out any maintenance or repair on the pump, make sure the it has been unplugged.

7.1.5 Fall Arrestor

- 1) Appearance inspection

Check if the shell, hook, steel wire are deformed, cracked, corroded or worn.

Check if the self-locking system is still working normally, if it is clogged or not smooth.

- 2) Function test

Manual fall simulation: quickly pull the safety rope to test if the self-locking system locks instantly (this should be done in a safe environment).

Check if the spring is functioning properly and ensure that the rope can be smoothly retracted without any jams.

- 3) Connection part

Confirm that the connection between the hook, safety rope and the fixed point is firm and reliable, without any looseness or deformation.

Check whether the steel wire rope/strap has any broken strands, burrs or chemical corrosion (contact with oil, acids or alkalis).

- 4) Labelling and Date

Check whether the information on the equipment nameplate (model, load capacity, production date) is clear.

Confirm that it is within the valid usage period

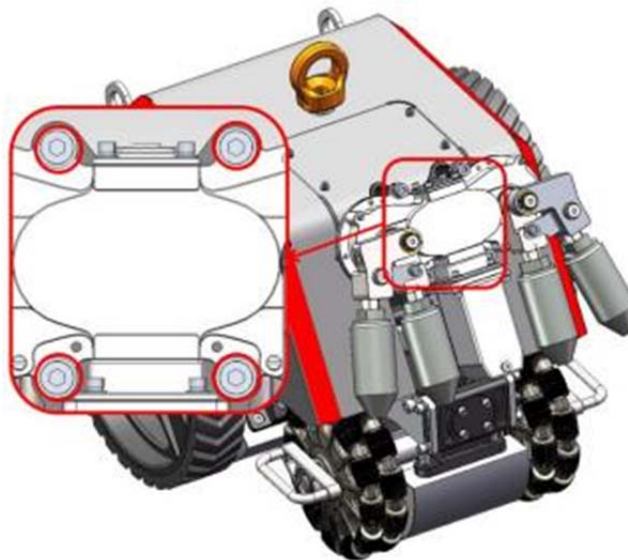
7.2 Repair

When conducting the maintenance of robots or performing component replacement operations, it is necessary to disassemble the robots. During the disassembly process, it is essential to proceed in an orderly manner strictly following the established procedures. At the same time, attention should be paid to the operation standards, and all actions should be carried out with gentle handling. Any rough operation may cause damage to the components, affecting their performance and service life, and even result in the loss of components, which will bring great inconvenience and safety hazards to the subsequent installation and use.

7.2.1 Rotation Nozzle Disassembly

The rotation nozzle can be disassembled as shown below:

- 1) Use an Allen key to remove 4 nuts

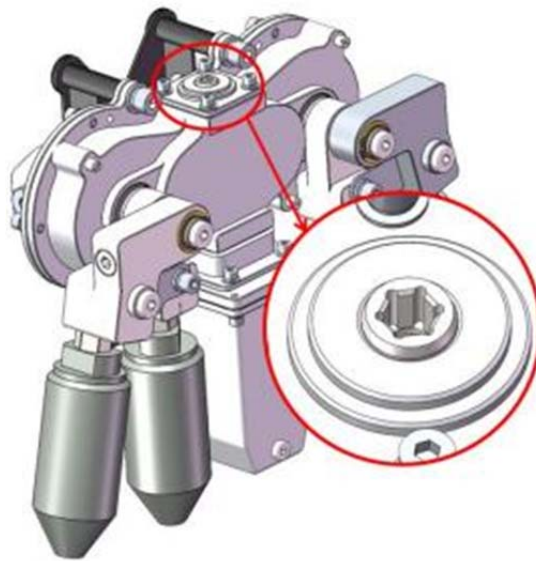


- 2) Slowly remove the upper part and disconnect the cable plug
- 3) Continue to pull outwards, be careful not to scratch the high-pressure hose
- 4) Remove and disassemble the electric rotation nozzle and store it properly
- 5) The nozzle can be assembled in the reverse order.



7.2.2 Rotation Nozzle Angle Manual Adjustment

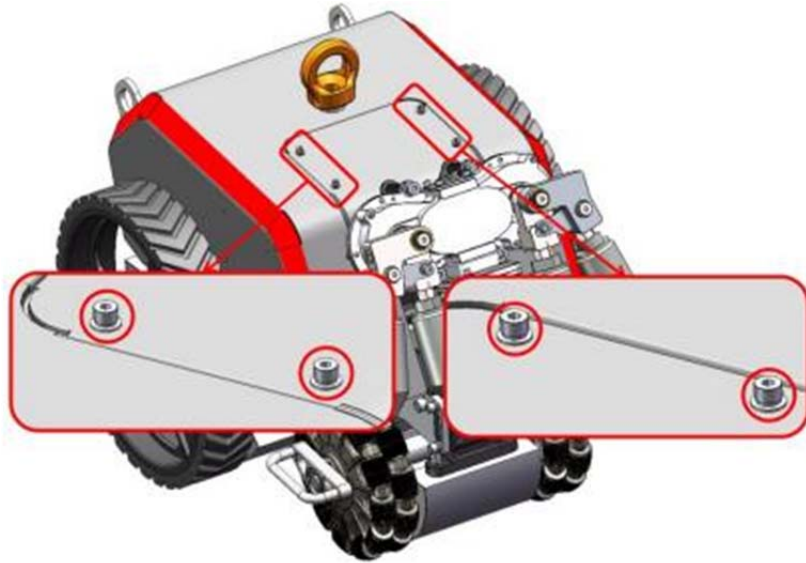
- 1) Insert an Allen key into the manual adjusting point



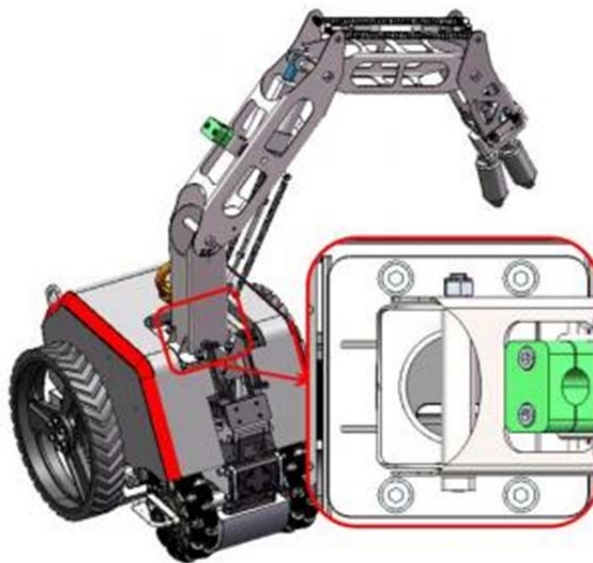
- 2) By turning the Allen key, the angle of the nozzle can be adjusted manually
- 3) The gearbox has a significant reduction ratio, meaning that for every 1.5 rotations of the Allen key, the nozzle rotates by 1 degree.

7.2.3 Extension Arm Assembly

- 1) Remove the rotation nozzle according to section **7.2.1 Rotation Nozzle Disassembly** to remove the rotation nozzle first if applicable.
- 2) Use an Allen key to unscrew the 4 nuts to remove the top cover.



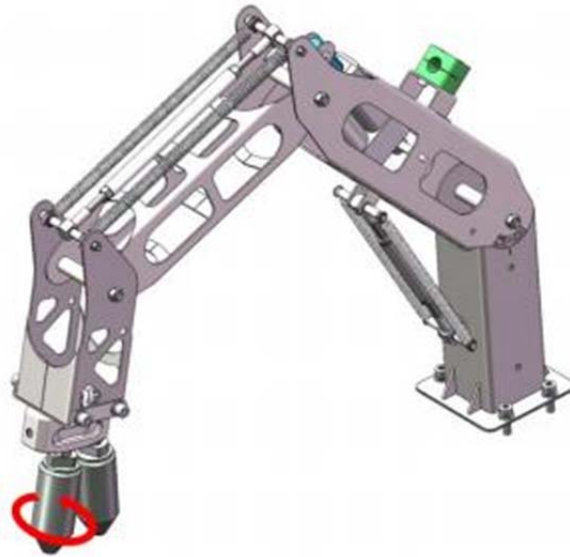
- 3) Keep the cover and nuts properly.
- 4) Put the extension arm in place above the robot and connect the power plugs and connectors.
- 5) Put the arm onto the robot frames and tighten the nuts.



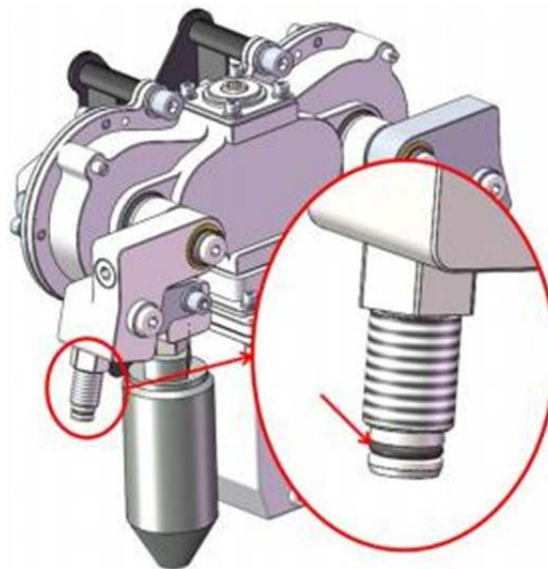
- 6) When installing the extension arm, make sure to insert the high pressure hose into the robot
- 7) The arm can be disassembled in the reverse order.

7.2.4 Changing the Nozzle

- 1) Rotate the nozzle in the anti-clockwise direction by hand can disassemble the nozzle.
- 2) Change the nozzle and tighten it clockwise.



- 3) During the assembly, pay attention to the O-ring on the connection parts of the nozzle in order not to damage the ring by the thread.



- 4) During disassembly, if the nozzle rotates together with the connection part, use a tool for help.
- 5) Insert the #20 open-end wrench or monkey wrench into the flat position of the nozzle
- 6) Insert the #17 open-end wrench into the hexagonal position of the nozzle connector
- 7) Rotate the #20 wrench anti-clockwise while keeping the #17 wrench stationary to complete the disassembly
- 8) The nozzle can be assembled in the reverse order.

7.2.5 Rotor Disassembly

- 1) Insert the #20 open-end wrench or monkey wrench into the flat surface of the nozzle, loosen the top shell in anti-clockwise direction



- 2) Keep the shell properly, reverse the nozzle to take out the rotor



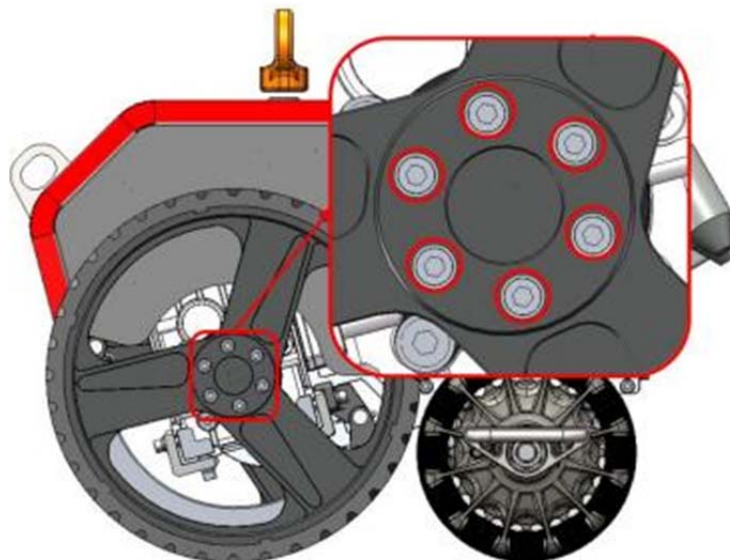
- 3) The rotor seat needs to be replaced together with the rotor. Use a tool to push it out



- 4) Replace new part, assemble the rotor seat in the reverse order
- 5) Put the rotor inside slowly, avoid colliding the sharp head of the rotor
- 6) Tighten the top shell, pay attention to the O-ring on the connection parts of the nozzle in order not to damage the ring by the thread
- 7) Replacement complete

7.2.6 Rubber Wheel Replacement

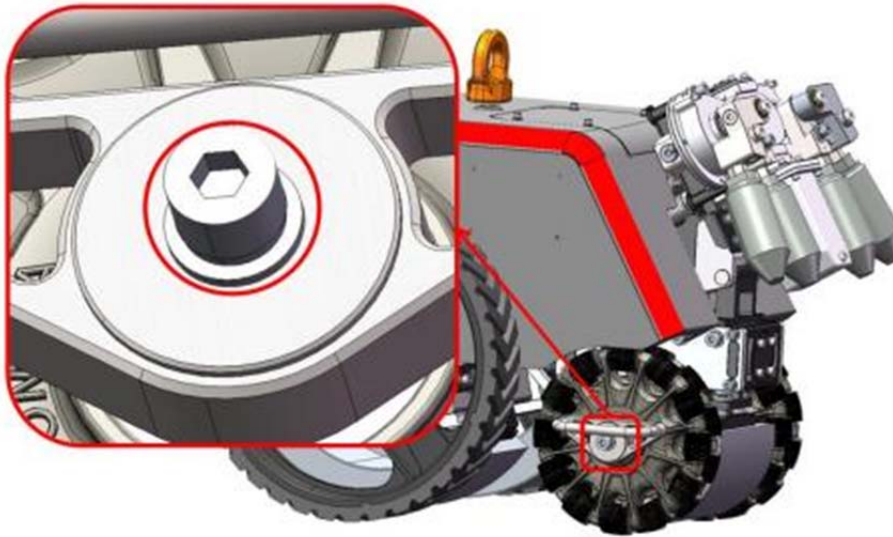
- 1) Use an Allen key to remove the 6 screws



- 2) Take out the wheel in the direction of the axis
- 3) Assemble the wheel back in the reverse order

7.2.7 Omni-directional Wheels Replacement

- 1) Use the Allen key to remove 1 nut as shown



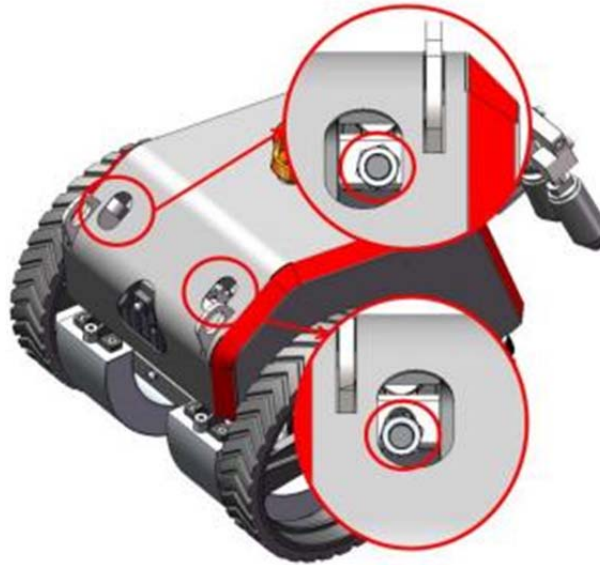
- 2) Take out the handle and keep it properly
- 3) Use a #24 wrench or monkey wrench to unscrew 1 nut and keep it



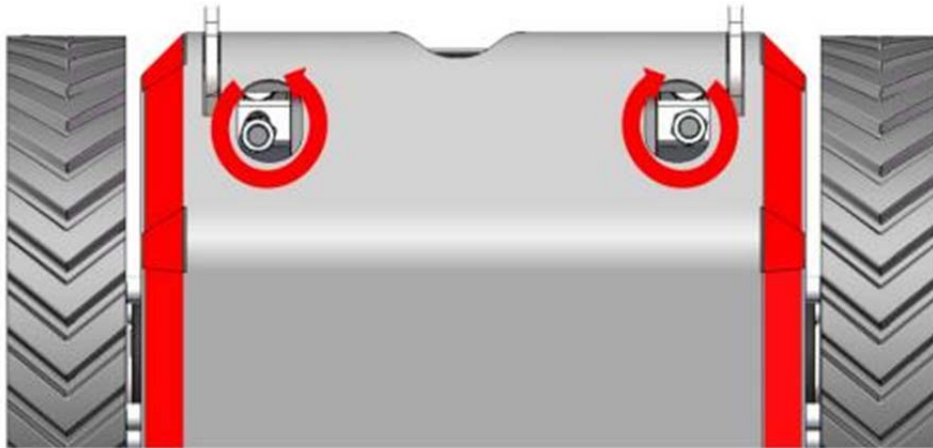
- 4) Take out the wheel in the direction of the axis
- 5) Assemble the wheel back in the reverse order

7.2.8 Magnet Distance Adjustment

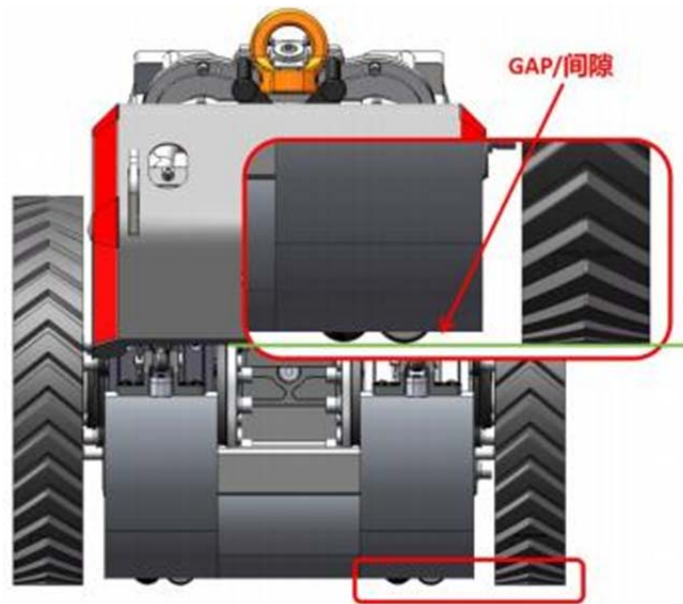
- 1) Use a #16 socket to insert from the hole and put it on the nut



- 2) Rotate the socket clockwise or anti-clockwise to adjust the magnet distance



- 3) Each time the socket rotates one circle, the distance is adjusted by 1mm
- 4) After the adjustment is completed, place the robot horizontally on a steel plate surface
- 5) Use a feeler gauge (or other accurate non-magnetic thickness material) to measure the minimum gap



- 6) The smaller the gap is, the larger the magnetic attraction force is, the poorer obstacle crossing ability will be
- 7) Complete the adjustment after finding a proper gap

7.2.9 Replacement of Remote Battery

- 1) Loosen the battery cover screw at the back of the remote control by hand



- 2) Open the cover, loosen and take out the battery slowly. Do not use too much force
- 3) Disconnect the battery from the remote



- 4) Replace the battery, insert it back to the connection point
- 5) Put the battery inside, put back the cover and tighten the screw

7.3 Maintenance

7.3.1 Robot

1) Nozzle

After each use of the nozzle, please thoroughly clean it with clean water and dry it

Apply lubricating grease on the surface and store it in a dry area

Before using it again, make sure the rotor of the nozzle can work normally.

2) Nameplate

After each use, please clean the robot's nameplate and ensure that the text is clearly visible.

3) Part Code

After each use, please clean the position where the robot part codes are located and ensure that the text is clearly visible.

7.3.2 Remote Control

The battery of the remote control needs to be charged when its power is low. If the battery is not used for a long time, please charge it regularly (once a month).

The battery charging operation is as follows:

- 1) Refer to **7.2.9 Replace of Remote Battery** to take out the battery
- 2) Connect the battery connector to the charger tightly
- 3) Plug the charger into the socket of the control cabinet for charging.

7.3.3 Fall Arrestor

- 1) Use a dry cloth to remove surface dust, and avoid rinsing with water (to prevent internal mechanisms from rusting).
- 2) Apply a small amount of anti-rust lubricant to the steel wire rope (avoiding the friction braking area).
- 3) Regularly send it to a professional institution for inspection, testing the locking response time and load-bearing capacity (such as annual mandatory inspections).

7.3.4 High Pressure Pump

The high pressure pump and its relevant parts need to be maintained regularly.

1) Lubrication

The crankshaft box lubricating oil should be replaced after the first 100 hours of use (lubricating oil grade: 75W90). After that, the lubricating oil should be changed every 300 hours.

Lubricating oil replacement: Turn off the pump unit. Remove the hexagonal cap (oil drain port) of the crankshaft box to drain the used oil and inject new lubricating oil. Observe through the glass window until it reaches the red dot on the top of the oil tank.



Used oil can pollute water sources and the environment. Please handle it carefully.

2) Cleaning

Please use clean water and a cloth for cleaning. Do not use strong chemical agents or high-pressure water for cleaning.

Please clean the motor and rear cooling fan cover regularly to allow sufficient cooling air flow for the motor.

7.4 Consumables List

Consumables, as those that require regular inspection and replacement, are of vital importance for maintaining the normal operation and stable performance of the equipment. Please strictly carry out the inspection work according to the prescribed frequency, and promptly replace the relevant parts when it is determined to be necessary through professional assessment.

No	Code	Module	Part Name	Specifications	Life
1	L2099000016	Driving Wheels	Rubber wheel	CBHV41-03.01.A	800 h
2	L3201020557		Reducer sealing gasket	SIC210-110.008.A	400 h
3	L3201020558		Waterproof spacer	SIC210-110.010.A	400 h
4	L3205090244		O-ring	ID 23.6mm×1.8mm	400 h
5	L3205090205		O-ring	ID 61.5mm×2.65mm	400 h
6	L3205090001		Oil seal	35mm*50mm*8mm	200 h
7	L3205150035		Hypoid reducer	BKM0503-125-ST60-V6	800 h
8	L3205060018	Omni- direction Wheels	Omni-directional wheel	R2-1812-95-002	800 h
9	L3205010260		Deep groove bearing	S6004ZZ	800 h
10	L3205010222		Oilless sleeve	JFB, 25×29×40/3×7×4 mm	200 h
11	L3201020559	Control Box	Control box sealing gasket	SIC210-200.004.A	400 h
12	L3205090226	Rotation Nozzle Module	O-ring	ID 30×1.8mm, black	400 h
13	L3205090279		O-ring	ID 160×1.8mm, black	400 h
14	L3205090240		O-ring	ID 7×2mm, black	400 h
15	L3205090215		O-ring	ID 6.07×1.78mm, yellow	400 h
16	L3205090288		O-ring	-	400 h
17	L3205090287		O-ring	-	400 h
18	L3205090325		Oil seal	17×26×5 mm	200h
19	L3205090319		Rotation seal	X51, ID 10mm, OD 22×7mm	200h
20	L3205090310		Glyd ring	G8, ID 17mm, OD 24.3×3.2mm	200 h

21	L3206010019	Nozzle	Connection seat	511104-1	800 h
22	L3206010020		Driving seat	511104-2	800 h
23	L3206010021		Shell	511104-3	800 h
24	L3205090312		O-ring	511104-4	400 h
25	L3205090313		O-ring	511104-5	400 h
26	L9002040078		Rotor	118-080	150 h
27	L9002040079		Rotor	118-100	150 h
28	L3206010022		Rotor seat	118-1	150 h

There are other long-lasting parts that do not have specific expect life, please check the actual wearing status and replace. The rest of the parts please refer to the part catalogue.

8. Fault Diagnosis and Troubleshooting

8.1 Electric Control System

8.1.1 Error Code

The robot can self-detect the current status. The information code will be shown on the remote control, code content as shown by the table below.

Error Code	Error Description	Remark
F007	Remote and robot connection timeout	Check if the antenna contact is good and the power supply is normal
F005	Cabinet and robot connection timeout	Check the connections Check if the output is 48V
F010	Cabinet emergency stop not released	Check the emergency stop button, release it if not
1/2-0001	Motor driver overvoltage	Check the power supply for left/right wheel set and power output
1/2-0002	Motor driver undervoltage	Check the power supply for left/right wheel set and power output
1/2-0004	Motor overcurrent	Check the power connection for left/right wheel set and if they are stuck
1/2-0008	Motor overload	Check the power connection for left/right wheel set and if they are stuck
1/2-0010	Current out of tolerance – reserved	Check the power connection for left/right wheel set and if they are stuck
1/2-0020	Encoder out of tolerance	Check the power connection for left/right wheel set and if they are stuck
1/2-0040	Speed out of tolerance	Check the power connection for left/right wheel set and if they are stuck
1/2-0080	Reference voltage error	Check if left/right driver is normal, if any water has entered
1/2-0100	EEPROM error	Left/right wheel set damaged
1/2-0200	Hall sensor error	Check the cable of left/right wheel set is in good contact, damaged or replace motor
1/2-0400	Motor overheats	Check if left/right wheel set has foreign bodies, if the loading is normal
1/2-0800	Driver overheats	Check the load of left/right wheel set, check if the driver is correctly installed
1/2-1000	Encoder error	Check if the cable of left/right wheel set is damaged, or replace motor

8.1.2 Control Cabinet Abnormal Power Supply

- 1) Check if the power supply cable connection is normal and if the plug is loose.
- 2) Check if the power supply cable and the plug are damaged. If so, please contact the manufacturer.
- 3) Check if there are obvious water traces in the electrical control cabinet. If there are, please check if the internal components are damaged. Please refer to **Annex 1 Electrical Control Cabinet Schematic Diagram**.
- 4) Check if there is any problem with the power supply.

8.1.3 Remote Control Start Failure

- 1) Check if the battery is charged;
- 2) Ensure that the battery connector is securely plugged into the remote control
- 3) Inspect if the remote control is damaged. If so, contact the manufacturer.

8.2 Robot

When abnormal situations occur during the operation of the robot, you can try to find solutions by referring to the following information. After strictly following the methods provided in the information for handling the issue, if the problem still cannot be effectively resolved, please contact the manufacturer promptly. We will be more than happy to provide you with professional technical support and services.

8.2.1 Robot No Response

- 1) Check the error code shown on the remote control. If there is an error, follow the instruction given at section 8.1.1 Error Code to troubleshoot the problem.
- 2) Check whether the cable plug connection is firm. If it is loose, reconnect the plug. If reconnecting the plug does not solve the problem, then check whether the plug is damaged. If it is damaged, replace the cable and the plug
- 3) Check if the cable is damaged. If it is damaged, replace the cable and the plug
- 4) Check if there are any obvious metal obstructions in between the remote control and the electrical control cabinet. If there is obstruction, move to another position for operation or the re-position the electrical control cabinet

8.2.2 Abnormal Vibration

- 1) Check if there are any foreign objects attracted on driving wheel magnets and the driven wheel magnet. If there are, remove them.
- 2) Check if the parts connecting the operation modules and the chassis are loose. If they are, tighten them.
- 3) Check if the locking screws of the driving wheels are loose. If they are, tighten them.
- 4) Check if there are any foreign objects on the driven wheel. If there are, remove them.
- 5) Check if the nozzle is loose. If it is, tighten it.
- 6) Reconnect the power supply, start the system, and check if the vibration is caused by the driving unit. If there is any abnormality, contact the manufacturer.

8.2.3 Abnormal Noise

- 1) Check if there are any foreign objects attracted on the driving wheel magnets and the driven wheel magnet. If there are any, remove them.
- 2) Check if the parts connecting the operation modules and the chassis are loose. If they are, tighten them.
- 3) Check if there are any foreign objects on the driving wheel. If there are, remove them.
- 4) Check if there are any foreign objects on the driven wheel. If there are, remove them.
- 5) Reconnect the power supply, start the system, and check if the noise is coming from the driving unit. If there is any abnormality, contact the manufacturer.

8.2.4 Abnormal Movement

- 1) Cut off the power supply of the system, rotate the driving wheel by hand, and feel if there is any obvious smooth resistance when the driving wheel rotates. If there is no resistance or if there is a significant jamming, then disassemble the motor compartment to check if the connecting shaft screws are loose. If they are loose, tighten them.
- 2) Reconnect the power supply, start the system, and check if there are any abnormalities in the driving unit. If there are any abnormalities, contact the manufacturer.

8.2.5 Serious Slippage

- 1) Check if there are any foreign objects on the driving wheels. If there are, remove them.
- 2) Check if there are any foreign objects attracted on the driving wheel magnets and the driven wheel magnet. If there are, remove them.
- 3) Check if the gap between the driving magnets is normal. If there is a large gap, adjust the gap to lower the height of the magnets and ensure that the minimum gap is greater than 6 mm.

- 4) Change the working area and observe if there is any slipping phenomenon. If there is, contact the manufacturer.
- 5) Cut off the water supply and observe if there is any slipping phenomenon. If there is, contact the manufacturer.

8.2.6 Rotation Nozzle Problem

- 1) Swing the nozzles with hand to check if they are loosened. If there is looseness, contact the manufacturer to replace the internal components.
- 2) Check if there are any fault codes on the remote control. If there are, refer to section **8.1.1 Error Code** for troubleshooting.
- 3) Use an Allen key to rotate the manual rotating point installed on the nozzle. Refer to section **7.2.2 Electric Nozzle Manual Adjustment** for the guide. If it cannot be rotated normally, contact the manufacturer.
- 4) Reconnect the power supply, start the system, and check if the oscillating push rod has any faults. If there are faults, contact the manufacturer.

8.2.7 Extension Arm Problem

If the extension arm fails to move when manually adjusting its position, please check if there are any foreign objects on the threads. If so, remove them. If the threads are deformed, contact the manufacturer to replace the parts.

If there is any abnormality with the electric push rod of the mechanical arm, please check:

- 1) Move the arm by hand to check if there is a large gap in the electric push rod. If there is a problem, contact the manufacturer to replace the parts.
- 2) Check if there are any error codes on the remote control. If there are, refer to section **8.1.1 Error Code** for fault diagnosis.
- 3) Check if the electric push rod has any obvious deformation or water infiltration. If there are any abnormalities, contact the manufacturer to replace the parts.

8.2.8 Nozzle Problem

- 1) If the nozzle leaks, it is necessary to check whether the internal O-ring is damaged. If there is a problem, it needs to be replaced.
- 2) If the nozzle vibrates strongly, it is necessary to check if there is any fluctuation in water pressure. If there is a problem, refer to section **8.2.10 Abnormal Water Pressure** for fault diagnosis.
- 3) If the rotor of the nozzle rotates unevenly or does not rotate at all, the rotor needs to be replaced.
- 4) If the water line of the nozzle becomes thicker and does not form a cone, the rotor needs to be replaced.

8.2.9 Poor Cleaning Result

- 1) Reduce the walking speed of the robot and try cleaning again
- 2) Decrease the distance between the nozzle and the surface to be cleaned, and try cleaning again
- 3) Check if the water line of the nozzle is rotating. If there is a problem, then the nozzle rotor needs to be replaced
- 4) Check if the water line of the nozzle has become thicker. If there is a problem, then the nozzle rotor needs to be replaced.
- 5) Check if the water supply of the high-pressure pump is sufficient. If there is a problem, then the nozzle can be used intermittently.
- 6) Check if there is a problem with the pressure of the high-pressure pump. If there is a problem, then the water pressure needs to be adjusted.

8.2.10 Abnormal Water Pressure

- 1) Conduct fault diagnosis on the high-pressure pump
- 2) Check if there is any leakage in the high-pressure hoses and connectors. If there is a problem, replace the high-pressure hose or the connectors.
- 3) Shorten the total length of the high-pressure hose and observe if the pressure has improved. If there is no improvement, contact the manufacturer

8.3 Other Auxiliary Equipment Fault

8.3.1 Cable Reel Brake Fault

Check if the brake spring of the cable car is damaged. If so, contact the manufacturer for replacement.

8.3.2 Cable Reel Cannot Rotate

- 1) Check if there are any foreign objects on the rotating shaft of the cable reel. If so, remove them.
- 2) Check if the rotating shaft of the cable reel has any deformation. If so, contact the manufacturer to replace it.

8.3.3 High Pressure Hose Abnormal Vibration

- 1) Check if there is any significant fluctuation in the pressure of the high-pressure pump. If so, conduct a fault diagnosis on the high-pressure pump.
- 2) Confirm if the bending radius of the high-pressure hose is less than the designed value. If so, contact the manufacturer for replacement.
- 3) 3Inspect if the high-pressure water hose is damaged. If so, contact the manufacturer for replacement.

8.3.4 Fall Arrestor Fault

If the fall arrestor has any problem, such as being unable to retract or not functioning properly, please contact the manufacturer for replacement.

8.3.5 Unloading Tool Cannot Attach

Check whether the magnets on the tool are damaged or fallen off. If so, contact the manufacturer for replacement.

8.3.6 Lifting Pulley Cannot Rotate

- 1) Check if there are any foreign objects on the sliding shaft part of the lifting pulley.
If so, remove them.

- 2) Check if there is any deformation on the sliding shaft part of the lifting pulley. If so, contact the manufacturer for replacement.

8.3.7 Lifting Pallet Cannot Move

- 1) Check if there are any foreign objects in the wheel part. If so, remove them.
- 2) Check if the wheel part has any deformation. If so, contact the manufacturer for replacement.

8.4 Other Fault or Errors

If the above-mentioned exception handling methods have not resolved the problem, in order to ensure that the equipment can continue operation as soon as possible, please contact the manufacturer promptly. The manufacturer will arrange professional technicians and quickly start the fault investigation.

The detailed information on product properties and availability is for reference only.

The scope of the delivered products and services performed is determined by the specific contract. Our company assumes no liability for any possible errors or omissions, and technical data is subject to change without notice.

FCC Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Radiation Exposure Statement

This device complies with FCC radiation exposure limits set forth for an uncontrolled environment and it also complies with Part 15 of the FCC RF Rules. This equipment must be installed and operated in accordance with provided instructions and the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. End-users and installers must be provided with antenna installation instructions and consider removing the no-collocation statement.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) this device may not cause harmful interference, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.

Caution!

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

