



ExR-2 and Docking Station

Operating Instructions

**LET'S DEVELOP
A ROBOT TOGETHER!**

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Contents

1. Introduction	3
2. Robot Configurations	3
3. Safety	3
3.1. Environment.....	3
3.2. Robot Deployment and Recovery.....	4
3.3. Docking Station Installation.....	5
3.4. Robot Operation.....	5
3.5. Robot Servicing.....	7
3.6. Robot Maintenance	7
4. Operating Characteristics	8
5. Marking	8
6. Certificates and Standards	9

ExRobotics B.V. ExR-2 and Docking Station Operating Instructions	Document No.: 20201102IP2 Version No.: 2	Owner: Ian Peerless	Date: 2021-04-16	Page 2 of 9
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1. Introduction

This document is one of two that will help operators to use their robot operators safely and effectively. The documents are the “Operating Instructions” and the “Operating Guide”. The former focuses on the safe operation of the robot especially with respect to its use in potentially explosive gas environments. The latter provides additional information about the robot’s controls. If there’s a conflict between the documents, the instructions prevail.

Because items in these instructions are essential for the safe, secure operation of the robot its wording will not be changed without the approval of ExRobotics’ quality owner and the certification authority.

2. Robot Configurations

ExR-2 robots are supplied with different options as detailed below.

Options	Comments
LiDAR module	
Power socket module	
High power induction charger	
Docking station	
Elevating mast	
Extra drive camera module	
Extra inspection module	
Falco VOC module	Ambient temp range -40C to +50C. Can be stored up to +60C
Crowcon hydrocarbon gas module	
Simtronics hydrocarbon gas module	
Honeywell toxic gas module 3000 MkII	Ambient temp range -20C to +55C
Honeywell toxic gas module Sensepoint XRL	
Det-tronics acoustic analyser module	
Eaton MEDC DB20 speaker	
Pepperl & Fuchs switches	Ambient temp range -40C to +50C
WiFi antenna	
Analynk WiFi or GPS module	
Electronics box check valve	Ambient temp range -30C to +60C

3. Safety

3.1. Environment

The robot platform and docking station are designed for:

- Ambient temperatures from -40C to +55C except when the range is limited by an option – See Section 2.
- Equipment protection level Gb (Zone 1 explosive gas environments).
- Explosion Group IIB (e.g. ethylene).
- Temperature class T4 (the robot’s maximum surface temperature is 135°C).
- Ingress protection IP45 (protected against objects >1mm, water jet resistant).

If ambient temperatures are forecast to be outside of the operating range, robots and docking stations will be stored in a protected location. If at any time a robot or docking station is exposed to conditions outside of its operating range it will be returned to ExRobotics for repair.

Robot operators can be charged in an Ex Zone 1 area using the docking station and induction charger at ambient temperatures from -40C to +55C.

ExRobotics B.V. ExR-2 and Docking Station Operating Instructions	Document No.: 20201102IP2 Version No.: 2	Owner: Ian Peerless	Date: 2021-04-16	Page 3 of 9
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When using a quick charger (plugged into the power socket module) the robot will only be charged in non-Ex locations with ambient temperatures between -40C and +45C.

The operator will ensure that the robot will not be used outside of these constraints and will consult ExRobotics if there's any doubt.

3.2. Robot Deployment and Recovery

A robot will not be deployed in potentially explosive environments if:

- Any of the glass windows is cracked or chipped. Glass windows can be found in sensors, inspection, camera, light, LiDAR, and communications modules.
- The hull is damaged to create a hole over 12mm wide.
- The plastic charger plate on the front of the robot is damaged.
- The emergency stop and on/off modules on top of the robot are damaged.
- There is significant damage that could compromise an Ex "d" module's ability to contain pressure. Ex "d" modules contain cameras, motors, lights, sensors and communications equipment.

Before deploying robots at a new location the site should be assessed for risks. Particular attention should be paid to:

- Drop-offs. If a robot falls under gravity it can inflict grievous harm to equipment and people. There is also a risk of sparks that could ignite potentially explosive atmospheres. It may be necessary to install barriers around drop-offs.
- Collision risks. If the robot collides with a fragile plant component (e.g. cables, control switches) or if a fragile external part of the robot (e.g. the inspection module, power socket, acoustic analyser, control switches, antennas or LiDAR) collide with the plant there's a risk of damage and sparks (electrostatic or electrical). It may be necessary to manage this risk by installing barriers, exclusion zones, or limiting the robot's operating parameters. For example there's less risk to the robot's fragile components and there's better situational awareness when the robot is driving forwards than there is when it's reversing. Similarly, if the robot collides with another item of equipment the combined energy could be enough to generate mechanical sparks that could ignite an explosive gas atmosphere. If the robot collides with a fragile plant component it's good practice to inspect it for damage using the robot's cameras. If the robot is involved in any significant collision it should be moved to a safe area and/or put to sleep until it can be inspected for damage.
- Driving on surfaces with high electrical resistance – e.g. very dry sand. The robot's equipotential bonding system grounds through the robot's tracks. If these are on a resistant surface, an electrical charge can accumulate in the robot. This could arc if the robot collides with a conductive structure and the arc could ignite a potentially explosive atmosphere.
- Non-ferrous metals such as aluminium alloys. If the robot collides with a non-ferrous metal or the aluminium inspection module on top of the robot collides with a ferrous material there's a risk of sparks that could ignite a potentially explosive atmosphere.
- Loose items that could be trapped between the robot's tracks and hull. If such objects exist, assess whether a trapped item might create enough friction heat to ignite a potentially explosive gas.
- Items that might be trapped between the docking station's and robot's induction chargers. If the gap between the charger plates is over 6mm the robot will not charge. If the gap is less than 6mm, assess whether during charging the object might heat up enough to ignite a potentially explosive gas. It's good practice to occasionally inspect the docking station and the front of the robot for such items using the robot's cameras.

ExRobotics B.V. ExR-2 and Docking Station Operating Instructions	Document No.: 20201102IP2 Version No.: 2	Owner: Ian Peerless	Date: 2021-04-16	Page 4 of 9
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A robot weighs between 90kg and 120 kg depending on its accessories. Ideally it should always be driven. Smartphones or Pads can be used to control a robot when the driver is on location and can see the robot.

If a robot cannot be driven be aware that:

- Pushing the robot for more than its own length may damage the drive electronics.
- Straps and forks can be placed under the hull.
- Robots should be lifted by four or five people wearing safety gloves and boots using the handles that are built into each side of the hull.
- When lifting a robot beware of its sharp antennas which can be at eye level. When transporting the robot it's usually best to unscrew the antennas and tape them to the robot's hull.

During transport a robot's emergency stop will be activated. This means it will easily roll forwards and backwards. Therefore, if the robot is not in a packing case or freight case it must be firmly secured to the transport.

3.3. Docking Station Installation

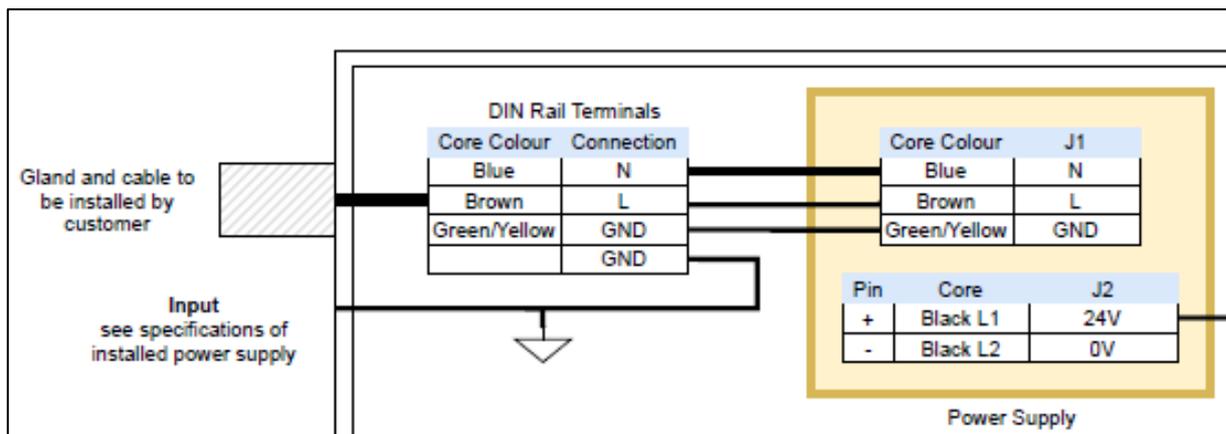
Docking stations and their control boxes are grounded via the supply cable's earth connection. The power supply in the control box, and the induction charger are protected by an 8A fuse in the power supply.

Docking stations will only be installed by qualified electricians. Installer to ensure power supply, switches, cables and fuses comply with all applicable standards and regulations. Power supply will be de-energised when control box is open.

If the docking station is installed in a potentially explosive gas environment the installers will follow the instructions for the control box. These can be downloaded from www.exrobotics.global. The supply cable can be installed through any of the M25 x 1.5 (6H) entries in the control box by removing any plug supplied by ExRobotics and installing a suitable Ex "d" gland or barrier gland. When using a regular gland the power supply cable will be at least 3 meters long.

The docking station will be connected to a 100 to 240 VAC supply with a fuse of no more than 20A to protect the connections in the control box.

Supply cables should be connected to the DIN Rail Terminals inside the control box as illustrated in the diagram below.



3.4. Robot Operation

Robots will only be charged on an ExRobotics docking station or using the optional power socket. If the robot is fitted with a power socket it will only be connected to a quick-charger supplied by ExRobotics and the socket's cap will be fastened closed when the robot is not being charged.

All people that visit the robot's deployment location should understand it's a potential trap/trip hazard.

ExRobotics B.V. ExR-2 and Docking Station Operating Instructions	Document No.: 20201102IP2 Version No.: 2	Owner: Ian Peerless	Date: 2021-04-16	Page 5 of 9
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Nothing should be attached to the robot without ExRobotics' permission since this could compromise its Ex certification. This includes labels, trailers, electrical instruments, or any other payload.

Robots can work in close proximity with people. However robots are designed to work independently and should not jointly perform operations with humans or other robots.

When robots are in operation they can travel at speeds up to 2 km/hour (0.6 m/s). Allowing for the latency between the control station and a robot, it can take up to 0.6m to stop. Therefore people should not approach within 1m of an operating robot (the safeguarded space).

Each robot has a range of stop options:

Name	Activated from	Purpose	Robot status when stop activated
On-off switch	Black switch on robot hull	Powers down the robot	A few very low power circuits in the electronics box remain powered up.
Emergency stop	Red mushroom on robot hull	Stops robot movement.	The drive motors and mast drive motor are isolated from their power supplies. All electronics boards remain powered up.
Protective stop	Red button on gamepad controller, & red icon on driver & viewer screens.	Stops robot movement	The power supplies to the drive module and mast drive module are disconnected in the electronics box. This isolates the power to the motor controller boards and the motors.
Drive control	Joystick on gamepad controller	Moving the robot	When joystick is released robot will slow to a halt until joystick is pressed again.
Communication loss	Robot automatically stops if wireless link from Driver is lost for 5 seconds	Ensures robot only moves if it can be monitored by a person	No motion commands are sent to the motors.
Line loss	Robot automatically stops if it's operating in basic autonomy mode and loses sight of the orange line.	Ensures robot does not stray from orange line	No motion commands are sent to the motors.
Collision avoidance	LiDAR (if fitted) and/or optical flow from inspection camera.	Prevents damage to robot & plant.	No motion commands are sent to the motors.
Collision detection	IMU, odometry and drive power data.	Reduces damage to robot & plant.	No motion commands are sent to the motors.
Drive/mast interface	Onboard robot software	Prevents damage to mast & plant	Mast cannot raise when robot is moving. Robot cannot move when mast is raised.

Robots will only be controlled with a computer connected to a gamepad controller because smartphones and pads do not have a physical emergency stop.

All people that visit the robot's deployment location should know how to use the red mushroom emergency stop switch. If someone needs to press it, he/she should approach the robot from its side. When the emergency stop is

ExRobotics B.V. ExR-2 and Docking Station Operating Instructions	Document No.: 20201102IP2 Version No.: 2	Owner: Ian Peerless	Date: 2021-04-16	Page 6 of 9
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pressed it disengages the drive motors which means the robot will roll under the influence of gravity. Be especially careful when pressing the emergency stop on an incline or ramp.

Robots should not be touched by anyone not familiar with the deployment and recovery instructions.

3.5. Robot Servicing

The LiDAR, drive camera, communications and inspection module windows, sensor windows, plastic induction charger plate and antennas will be cleaned with a damp, soft cloth.

If necessary, jet washing can be used to de-contaminate the robot. However after washing, the battery pack will be opened and if necessary, the inside will be dried before the box is closed again.

The robot and its components will not be opened in a hazardous area or explosive atmosphere.

The following parts are user-serviceable:

- A robot’s batteries can be replaced with 3 off Green Rhino 12-GRGS-14 (Beta or Upergy 6 CNFJ-14) batteries. After removing the old batteries check that the foam strips are securely attached to the inside of the battery pack. Replace any that are loose with strips supplied by ExRobotics.
- A robot’s hull can be opened to replace a SIM card, to calibrate gas detectors, to change the nose of a Honeywell toxic gas module, or to install/swap a gas module. Only modules approved by ExRobotics will be installed and this will be done by a qualified electrician that is trained in Ex certification.
- The SIM card is located in the communications module. When changing this take care not to damage the module’s flameproof joint and when closing the module torque its lid’s bolts to 7 Nm.
- Always close a robot’s hull before re-deploying it in a potentially explosive gas environment. Ensure all of the fasteners are re-installed. There should be no gaps in the hull wider than 12mm.
- Tracks can be replaced but they must be supplied by ExRobotics otherwise a robot’s equipotential grounding path may be compromised and there may be a risk of sparks generated by static electricity.

3.6. Robot Maintenance

The bearings in the robot’s drive module, mast drive module, and panning inspection module should need no maintenance. However, if the bearings are damaged there’s a risk that they could generate enough heat to ignite a potentially explosive gas atmosphere. Therefore if there’s any evidence of damage (e.g. loose shafts or grinding noises) contact ExRobotics.

For information:

- Do not repair the flameproof joints of robots or any of their components.
- Flameproof joints are closed using fasteners with a yield stress $\geq 450 \text{ Nmm}^2$.
- Do not repair robots’ electronics boxes or any other components that are not mentioned in the section on Robot Servicing.

If fitted, the elevating mast should be maintained and its springs replaced in accordance with the instructions provided with the mast.

Any faulty robot will be returned to ExRobotics for repair. Please contact sales@exrobotics.global or visit www.exrobotics.global for more information.

ExRobotics B.V. ExR-2 and Docking Station Operating Instructions	Document No.: 20201102IP2 Version No.: 2	Owner: Ian Peerless	Date: 2021-04-16	Page 7 of 9
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4. Operating Characteristics

The power contained in each robot and docking station is less than 1300 Watts.

The operating characteristics for Ex certified components are specified in their instructions. The electrical characteristics of components that are integral to the robot's certification are as follows.:

Component	DC voltage	Maximum current	Maximum peak power	Maximum short circuit current
Battery pack output	36 V nominal.	20 A	<1300 W	470 A
Electronics box	1.8 to 36 V	20 A	<1300 W	20 A

The options for charging the battery pack are as follows:

- Docking station – Maximum current 3A, maximum voltage 43.2V.
- Quick charger – Maximum current 5A, maximum voltage 45V.

U_m is 240V when the robot is connected to a charger. All of these figures are at room temperature. Once the battery is fully charged all options trickle charge the battery.

The **microphone** operates at less than 3 VDC, consumes less than 0.5 mA, has an output impedance of 2.2 kΩ and a capacitance of <1 μF.

The maximum transmitted **wireless power** when using 4G, 3G or WiFi communications is 1W.

A robot's hull and its components form an **equipotential bonding system**. The resistance between any part of this system and the ground will not exceed 10⁹ Ω.

5. Marking

The nameplates on the robots and docking stations include important certification information including the operating temperature range:

		ExRobotics B.V. Effenseweg 1 4838 BA Breda The Netherlands	
CE 0539	Date of manufacture	September 2021	
ExR-2 Robot Operator	Weight	100kg	
ExR-SW-003377	Serial number	#202	
IECEX UL 21.0025X	UL 21 ATEX 2535X	UL 21 ATEX 2536X	
Ex 60079-46 IIB T4 Gb	II 2 G Ex db eb ib mb q IIB T4 Gb	Ex h IIB T4 Gb	
-40°C ≤ Ta ≤ +55°C	See Instructions		
⚡ Total power housed < 1300 W • Um = 240V • Operating < 45 V DC			
 WARNING OPEN ONLY IN NON-HAZARDOUS AREA		 WARNING MAINTENANCE TO BE PERFORMED ONLY BY EXROBOTICS' APPROVED COMPANIES	

		ExRobotics B.V. Effenseweg 1 4838 BA Breda The Netherlands	
CE 0539	Date of manufacture	September 2021	
ExR-2 Docking Station	Weight	25kg	
DCR-SW-003721	Serial number	#001	
Part of IECEx UL 21.0025X UL 21 ATEX2535X UL 21 ATEX2536X			
IEC 61439-1			
-40°C ≤ Ta ≤ +55°C See Instructions			
⚡ Total power housed < 1300 W • Um = 240V			
 WARNING OPEN ONLY IN NON-HAZARDOUS AREA		 WARNING CONNECT TO A 100 TO 240 VAC POWER SUPPLY WITH A 20A FUSE,	
 WARNING MAINTENANCE TO BE PERFORMED ONLY BY EXROBOTICS' APPROVED COMPANIES			

ExRobotics B.V. ExR-2 and Docking Station Operating Instructions	Document No.: 20201102IP2 Version No.: 2	Owner: Ian Peerless	Date: 2021-04-16	Page 8 of 9
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