ExR-1 Rev 3 and Docking Station

Operating Instructions

LET'S DEVELOP
A ROBOT TOGETHER!

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ROBOTICS

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Document Change Log:

Version #	Date of issue	Changes Made	Page	Author of Change
1	2020-11-02	Issued to Certification Authority		Ian Peerless
2	2021-04-27	Final version for approval		Ian Peerless
3	2021-06-08	Version for ExR1-Rev3		Tim Vercruyssen
4	2021-07-20	Adjusted Certification and standards	8	Tim Vercruyssen

Contents

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-1 REV3 robots are supplied with different options as detailed below.

Options	Comments
Light module	
Power socket module	
High power induction charger	
Docking station	
Extra inspection module	multiple configurations possible
Falco VOC module	
Crowcon hydrocarbon gas module	
Simtronics hydrocarbon gas module	
Honeywell toxic gas module 3000 MkII	
Honeywell toxic gas module Sensepoint XRL	
Pepperl & Fuchs switches	
WiFi antenna	
IR leak detection module	
Electronics box check valve	Reduces the risk of condensation in the box.

3. Safety

3.1. Environment

The robot platforms are designed for:

- Ambient temperatures from -20C to +50C.
- 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^{o}C).
- Ingress protection IP45 (protected against objects >1mm, water jet resistant).

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

The robot platforms will be charged in a safe zone (i.e. there is no potentially explosive gas).

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, camera modules, IR modules, and light 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 optical and IR cameras, motors, lights, and sensors.
- The Ex label is damaged in a way that suggests that the hull has been opened.

Before deploying robots at a new location the site should be assessed for risks. Pay particular attention 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.
- Collision risks. If the robot collides with a fragile plant component (e.g. cables, controls) or if a fragile external part of the robot (e.g. the camera module, light module, power socket, control switches, or antennas) collides 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 - 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.
- If the robot hull (which is made of aluminium) collides with a ferrous metal 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.

A robot weighs between 70kg and 100 kg depending on the options fitted. 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 can be lifted by four people wearing safety gloves and boots. They should place their hands under the bottom of the tracks where they’re supported by the metal tray, under the camera housing and under the rear of the hull. Do not hold the tops of the tracks because they may rotate and trap a hand between the track and a sprocket.
- 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

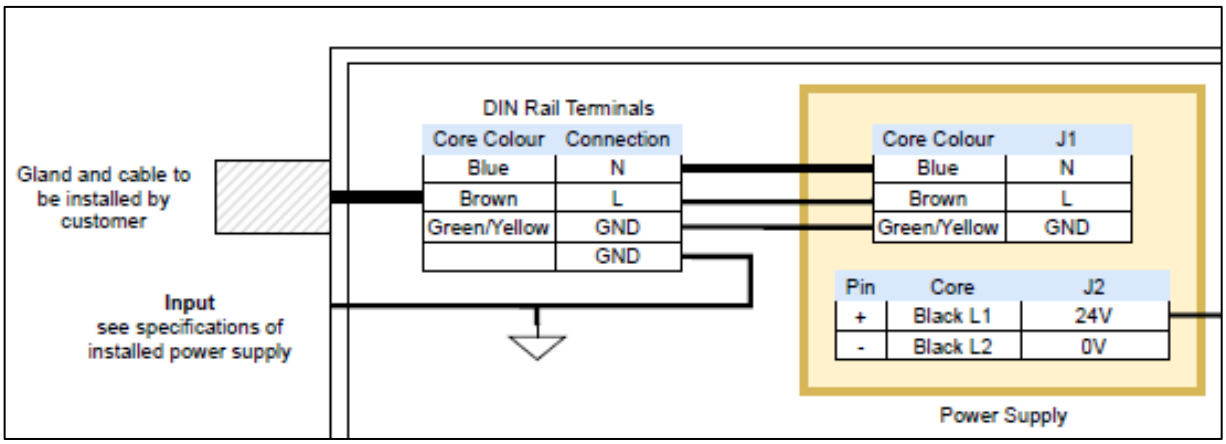
Docking stations and their control boxes are grounded via the supply cable's earth connection. The power supply in the control box, and the induction charger are protected by a fuse. The fuse value corresponds to the input protection of the installed power supply.

Docking stations will only be installed by qualified site 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.

The docking station for ExR-1 can only be installed outside a potentially explosive gas environment. 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 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.

Charging (Both induction and fast charging) of the robot is not allowed in a potentially explosive gas environment.

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

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 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 supply to the drive module is 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	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.

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 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 camera and light windows, plastic charger plate and antennas will be cleaned with a damp, soft cloth.

Apart from the tracks and the "nose" of the optional Honeywell gas detectors, none of the robot's components are user-serviceable or replaceable. Its Ex label will be attached across the joint between the hull plates and the robot's warranty will be invalidated if the label is broken. This means that the robot and its components will not be opened in a hazardous area or explosive atmosphere.

Replacement tracks must be supplied by ExRobotics otherwise the robot's equipotential grounding path may be compromised and there may be a risk of sparks generated by static electricity.

If the robot is fitted with an Over Current Protection system and it trips during operation ExRobotics will be informed. The condition of the batteries will be assessed when the robot is maintained and in any case within 6 months.

The battery pack contains 3 off 12-GRGS-7.2, 12-HGRGS-7.2, 6-CNFJ-7.2, or 6-HCNFJ-7.2 batteries but is not to be opened.

3.6. Robot Maintenance

The bearings in the robot's drive 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 ≥ 450 Nmm^2.
- Do not repair robots' electronics boxes or any other components that are not mentioned in the section on Robot Servicing.

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

4. Operating Characteristics

The power contained in each robot 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
Electronics box	1.8 to 36 V	20 A	<1300 W	20 A

The options for charging the battery pack are as follows:

Low power induction charger – 43.2 VDC supply with a maximum current of 700 mA.
High power induction charger – 43.2 VDC supply with a maximum current of 3A.
Low power cable charger – 2.5 A supply until battery charge is 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.

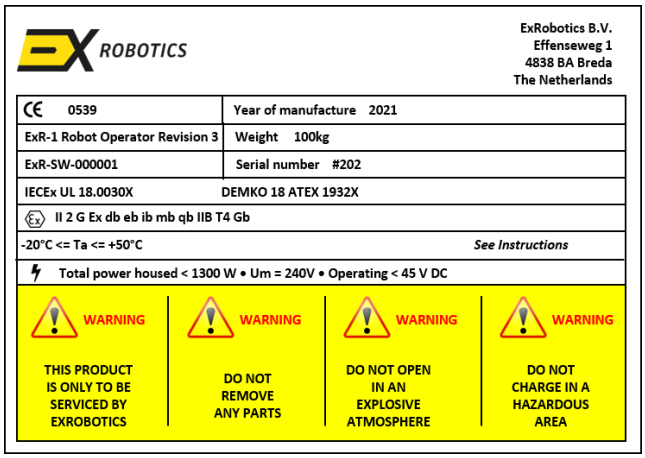
The **microphone** operates at less than 3 VDC, consumes less than 0.5 mA, has an output impedance of 2.2 kΩ and a capacitance of <1 μF.

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 10^9 Ω.

5. Marking

The nameplate on the robot includes important certification information including a robot's operating temperature range:



6. Certificates and Standards

The robot operators are certified to operate in Zone 1 environments in accordance with:

• IEC 60079-0, Edition 7	EN IEC 60079-0:2018
• IEC 60079-1 Edition 2014	EN 60079-1:2014
• IEC 60079-5 Edition 2015	EN 60079-5:2015
• IEC 60079-7 Edition 5.1	EN IEC 60079-7: 2015 +A1:2018
• IEC 60079-11 Edition 2011	EN 60079-11:2012
• IEC 60079-14 Edition 2013	EN 60079-14:2014
• IEC 60079-18 Edition 4.1	EN 60079-18:2015+A1:2017