

COLD ENVIRONMENT CALIBRATION PROCEDURE

Document ID: PDR-CAL-2023-014

Version: 3.1

Effective Date: January 15, 2024

Classification: CONFIDENTIAL - PROPRIETARY INFORMATION

Owner: Polar Dynamics Robotics, Inc.

1. PURPOSE AND SCOPE

1. This Cold Environment Calibration Procedure ("Procedure") establishes the standardized methodology for calibrating Polar Dynamics Robotics, Inc.'s ("Company") autonomous mobile robots ("AMRs") for operation in controlled temperature environments below 0 C (32 F).
2. This Procedure applies to all Series X-200 and X-300 AMRs equipped with IceNav(TM) navigation systems and CryoTech(TM) actuators intended for deployment in cold storage facilities, freezer environments, and temperature-controlled logistics operations.

2. DEFINITIONS

1. "Calibration Environment" means a temperature-controlled testing facility capable of maintaining stable temperatures between +20 C and -40 C.
2. "IceNav(TM) System" means the Company's proprietary navigation and control system designed for cold environment operations.
3. "CryoTech(TM) Actuators" means the Company's cold-resistant robotic actuator assemblies.
4. "Thermal Equilibrium" means the state where all AMR components have reached stable operating temperature within 1 C.

3. CALIBRATION PREREQUISITES

1. Required Equipment:
 - Certified temperature monitoring system
 - Digital inclinometer (accuracy 0.1)
 - Laser alignment tool (Class 2 or better)

- Calibrated torque measurement device
- Company-approved diagnostic interface

2. Environmental Conditions:

- Ambient temperature stability: 0.5 C
- Relative humidity: <65%
- Air flow rate: <0.5 m/s
- Level surface (maximum deviation 0.5)

4. CALIBRATION PROCEDURE

1. Initial Setup

- a) Power down AMR completely
- b) Allow minimum 4 hours for thermal equilibration at target temperature
- c) Verify battery charge level >85%
- d) Connect diagnostic interface
- e) Initialize IceNav(TM) system in diagnostic mode

2. Sensor Calibration

- a) Verify all sensor heating elements are functional
- b) Calibrate LIDAR units at 5 increments from +20 C to -40 C
- c) Adjust infrared sensor sensitivity coefficients
- d) Validate proximity sensor range accuracy
- e) Document all calibration values in the system log

3. CryoTech(TM) Actuator Calibration

- a) Perform zero-point calibration for each actuator
- b) Measure torque response curves at specified temperature points
- c) Update thermal compensation parameters
- d) Verify emergency stop functionality
- e) Record actuator performance metrics

5. VALIDATION REQUIREMENTS

1. Navigation Accuracy Test

- Minimum 50 waypoint navigation cycles
- Maximum positioning error: 15mm
- Heading accuracy: 0.5
- Path repeatability: 25mm

2. Performance Metrics

- Acceleration response time: <250ms
- Stopping distance: <500mm at 1.5 m/s
- Battery performance deviation: <10%
- Motor temperature stability: 3 C

6. DOCUMENTATION AND REPORTING

1. Required Records

- Calibration date and location
- Serial numbers of AMR and major components
- Environmental conditions throughout procedure
- All measured values and adjustments
- Validation test results
- Technician identification and certification number

2. Data Retention

- All calibration records shall be maintained for minimum 5 years
- Electronic backup required within 24 hours
- Secure storage in Company's technical documentation system

7. QUALITY ASSURANCE

1. This procedure shall be reviewed annually and updated as required.

2. Only Company-certified technicians with current cold environment certification may perform this procedure.

3. Any deviations from specified parameters must be documented and approved by Quality Control.

8. PROPRIETARY INFORMATION NOTICE

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9. REVISION HISTORY

Version 3.1 - January 15, 2024

- Updated sensor calibration parameters
- Added new validation requirements
- Revised documentation requirements

Version 3.0 - July 1, 2023

- Major revision incorporating X-300 series requirements
- Updated environmental specifications

Version 2.1 - January 10, 2023

- Initial release for X-200 series

APPROVAL

APPROVED BY:

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Dr. James Barrett

Chief Robotics Officer

Polar Dynamics Robotics, Inc.

Date: January 15, 2024