COLD ENVIRONMENT PERFORMANCE TEST RESULTS

Q4 2023 Validation Report

Polar Dynamics Robotics, Inc.

Document Reference: PDR-TEST-2023Q4-CE-001

1. EXECUTIVE SUMMARY

This document presents the official cold environment performance test results for Polar Dynamics Robotics' IceNav(TM)-enabled autonomous mobile robots (AMRs) conducted during Q4 2023. Testing was performed in accordance with ISO 13849-1:2015 safety requirements and ANSI/RIA R15.08-1-2020 industrial mobile robot standards.

2. TEST PARAMETERS

1. Test Period

- Start Date: October 1, 2023
- End Date: December 31, 2023
- Total Test Hours: 2,160

2. Test Environment Specifications

- Primary Test Facility: PDR Cold Operations Laboratory (Dover, DE)
- Secondary Validation Site: Third-party certified testing facility (T V S D, Minneapolis, MN)
- Temperature Range: +5 C to -40 C
- Humidity Range: 15% to 85% RH
- Floor Conditions: Varied (concrete, epoxy, steel plate)

3. EQUIPMENT TESTED

1. Test Units

- Model: PDR-AMR-3000-ICE
- Serial Numbers: ICE-23-1001 through ICE-23-1005
- Firmware Version: 4.2.8
- IceNav(TM) Software Version: 2.3.5

2. Critical Components

- Cold-resistant actuators (Patent #US11,234,567)
- Thermal management system v3.2
- Enhanced battery system with cold-weather optimization
- Hardened sensor package with defrost capabilities

4. TEST PROCEDURES

1. Standard Operating Procedures

- SOP-CE-001: Cold Start Protocol
- SOP-CE-002: Continuous Operation Assessment
- SOP-CE-003: Navigation Accuracy Validation
- SOP-CE-004: Emergency Stop Functionality
- SOP-CE-005: Battery Performance Analysis

2. Special Test Conditions

- Rapid temperature cycling
- Simulated frost accumulation
- Power interruption recovery
- Multi-unit interaction scenarios

5. TEST RESULTS

1. Performance Metrics

- Cold Start Success Rate: 99.7%
- Navigation Accuracy: 2.3cm at -30 C
- Battery Life: 12.4 hours at -25 C
- Emergency Stop Response: <100ms at all temperatures
- Sensor Reliability: 99.9% uptime

2. Critical Findings

- All units maintained Class A performance rating
- Zero critical failures during 2,160-hour test period
- Navigation accuracy exceeded specification requirements

- Thermal management system performed within design parameters

6. COMPLIANCE VERIFICATION

1. Safety Standards

- ISO 13849-1:2015 Performance Level D achieved
- ANSI/RIA R15.08-1-2020 compliance verified
- CE marking requirements satisfied
- UL 3300 certification maintained

2. Environmental Standards

- IP65 rating confirmed for all enclosures
- EMC compliance verified per IEC 61000-6-2
- RoHS 3 (EU 2015/863) compliance maintained

7. LIMITATIONS AND DISCLAIMERS

The test results contained herein are valid only for the specific units tested under controlled laboratory conditions. Actual performance may vary based on environmental factors, usage patterns, and maintenance procedures. This document is confidential and proprietary to Polar Dynamics Robotics, Inc.

8. CERTIFICATION

The undersigned hereby certify that the tests described in this document were conducted in accordance with applicable standards and Polar Dynamics Robotics' quality management system requirements.

Test Director:

Dr. Michael Winters

Director of Quality Assurance

Polar Dynamics Robotics, Inc.

Date: January 10, 2024

Technical Reviewer:

Sarah Chen, P.E.

Senior Test Engineer

Polar Dynamics Robotics, Inc.

Date: January 10, 2024

9. APPENDICES

1. Raw Data References

- Test Log Files: PDR-Q4-23-LOG-001 through PDR-Q4-23-LOG-125
- Sensor Data: Available upon request (Reference: SEN-Q4-23)
- Video Documentation: Available upon request (Reference: VID-Q4-23)

2. Related Documentation

- Full test protocols available in PDR Technical Library
- Calibration certificates for test equipment
- Environmental chamber certification records

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