

COLD ENVIRONMENT TESTING PROTOCOL

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Classification: Confidential & Proprietary

1. PURPOSE AND SCOPE

1. This Cold Environment Testing Protocol ("Protocol") establishes the standardized procedures and requirements for testing Polar Dynamics Robotics, Inc.'s ("Company") autonomous mobile robots ("AMRs") and related systems in controlled cold environment conditions.

2. This Protocol applies to all Company products designated for operation in sub-zero environments, including but not limited to the Arctic Series(TM) AMRs, IceNav(TM) navigation systems, and CryoTech(TM) actuators.

2. DEFINITIONS

1. "Cold Environment" means any controlled testing environment with ambient temperatures between -40 C and +5 C.

2. "Test Unit" refers to any Company AMR, subsystem, or component undergoing cold environment testing.

3. "Testing Facility" means Company's ISO/IEC 17025:2017 certified cold chamber testing facility located at 4501 Industrial Drive, Dover, Delaware.

4. "Critical Systems" includes primary locomotion systems, battery systems, sensor arrays, and IceNav(TM) navigation components.

3. TESTING REQUIREMENTS

1. Environmental Parameters

- Temperature range: -40 C to +5 C
- Humidity range: 20% to 95% RH
- Air velocity: 0.5 to 2.0 m/s

- Testing duration: Minimum 72 hours continuous operation

2. Performance Metrics

- Navigation accuracy within 5mm at -30 C
- Battery performance degradation <15% at -25 C
- Actuator response time <100ms at -35 C
- Sensor data reliability >99.9% at all test temperatures

4. TESTING PROCEDURES

1. Pre-Test Requirements

- a) Complete system diagnostic baseline at room temperature (20 C ± 2 C)
- b) Verify all sensors are calibrated within 90 days
- c) Document initial conditions and test unit configuration
- d) Install temperature monitoring devices at specified locations

2. Testing Sequence

- a) Stage 1: Gradual temperature reduction (2 C per minute)
- b) Stage 2: Steady-state operation at target temperature
- c) Stage 3: Dynamic load testing under cold conditions
- d) Stage 4: Recovery phase monitoring

3. Data Collection

- a) Continuous logging of all sensor data
- b) Video documentation of critical test phases
- c) Power consumption metrics at 1-second intervals
- d) Thermal imaging at 15-minute intervals

5. SAFETY AND COMPLIANCE

1. All testing must comply with:

- ANSI/RIA R15.06-2012 Safety Requirements
- ISO 10218-1:2011 Robot Safety Standards
- Company Safety Protocol PDR-SAF-2023-005

2. Emergency Procedures

- a) Automated shutdown if temperature exceeds limits
- b) Emergency stop system testing every 8 hours
- c) Backup power system verification
- d) Personnel safety protocols per Section 7.3

6. DOCUMENTATION AND REPORTING

1. Required Documentation

- Test Plan Approval Form (Form PDR-TP-101)
- Environmental Condition Log (Form PDR-EC-102)
- System Performance Data Sheets (Form PDR-PD-103)
- Incident Reports (if applicable)

2. Report Requirements

- a) Executive summary
- b) Raw data appendices
- c) Performance analysis
- d) Deviation documentation
- e) Certification of results

7. INTELLECTUAL PROPERTY PROTECTION

- 1. All test data, methodologies, and results are confidential and proprietary to the Company.
- 2. Testing personnel must have executed current NDAs (Form PDR-HR-201).
- 3. No photography or recording devices permitted in testing facility without written authorization.

8. QUALITY ASSURANCE

- 1. Testing facility must maintain ISO 9001:2015 certification.
- 2. Quarterly calibration of all testing equipment required.
- 3. Annual audit of testing procedures by Quality Assurance Department.

9. PROTOCOL MAINTENANCE

1. This Protocol shall be reviewed annually by the Chief Robotics Officer.

2. Revisions require approval from:

- Chief Technology Officer
- Quality Assurance Director
- Legal Department

10. AUTHORIZATION

This Protocol is authorized and approved by:

—

Dr. James Barrett

Chief Robotics Officer

Polar Dynamics Robotics, Inc.

Date: _

—

Marcus Chen

Chief Technology Officer

Polar Dynamics Robotics, Inc.

Date: _

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