

OPERATIONS DOCUMENT 385

STANDARD OPERATING PROCEDURES FOR AUTONOMOUS MOBILE ROBOT DEPLOYMENT AND MAINTENANCE IN TEMPERATURE-CONTROLLED ENVIRONMENTS

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1. PURPOSE AND SCOPE

1 This Standard Operating Procedure ("SOP") establishes the mandatory operational protocols for the deployment, maintenance, and decommissioning of Polar Dynamics Robotics, Inc. ("Company") autonomous mobile robots ("AMRs") in temperature-controlled environments ranging from -40 C to +25 C.

2 This document applies to all Series X-500 and X-700 AMR units incorporating IceNav(TM) navigation systems and ColdCore(TM) actuator technology.

2. DEFINITIONS

1 "Cold Zone Operation" refers to any deployment environment maintained below 0 C.

2 "Thermal Transition Protocol" means the Company's proprietary procedure for transitioning AMR units between temperature zones.

3 "Mission-Critical Systems" include primary locomotion, navigation, safety, and communication subsystems.

4 "IceNav(TM) Calibration" refers to the process of optimizing environmental sensors and navigation parameters for specific deployment conditions.

3. PRE-DEPLOYMENT PROCEDURES

1 Environmental Assessment

a) Conduct full thermal mapping of deployment zone

- b) Document all transition areas between temperature zones
- c) Verify floor surface conditions and friction coefficients
- d) Map RF interference patterns and communication dead zones

2 Unit Preparation

- a) Execute full diagnostic sequence per Technical Bulletin TB-2023-15
- b) Verify ColdCore(TM) actuator thermal management system calibration
- c) Install environment-specific firmware version as specified in Appendix A
- d) Configure IceNav(TM) parameters for target operating temperature

4. OPERATIONAL PROTOCOLS

1 Cold Zone Entry Sequence

- a) Initiate thermal conditioning cycle minimum 30 minutes prior to zone entry
- b) Verify actuator temperature within 2 C of operational specifications
- c) Conduct safety system verification per Checklist CZ-101
- d) Log entry event in facility management system

2 Continuous Operation Requirements

- a) Maintain 24/7 telemetry monitoring via Operations Control Center
- b) Record thermal stress cycles per unit
- c) Monitor battery performance metrics hourly
- d) Execute automated diagnostics every 4 hours

5. MAINTENANCE REQUIREMENTS

1 Scheduled Maintenance

- a) Perform Level 1 inspection every 168 operating hours
- b) Complete full thermal system evaluation every 720 operating hours
- c) Replace thermal interface materials per schedule in Appendix B
- d) Calibrate environmental sensors monthly

2 Unscheduled Maintenance

- a) Investigate any thermal anomaly exceeding 3 C from specification

- b) Document all fault conditions in maintenance log
- c) Replace components showing thermal stress indicators
- d) Perform full system validation after any component replacement

6. SAFETY PROTOCOLS

1 Emergency Shutdown Procedures

- a) Implement immediate shutdown if thermal runaway detected
- b) Execute emergency extraction sequence if communication lost
- c) Maintain minimum 3-meter separation from personnel in Cold Zones
- d) Follow lockout/tagout procedures during maintenance

2 Personnel Requirements

- a) Maintain current cold environment certification
- b) Use approved cold weather PPE when servicing units
- c) Follow buddy system protocol for Cold Zone entry
- d) Complete quarterly safety refresher training

7. COMPLIANCE AND DOCUMENTATION

1 All maintenance activities must be logged in the Company's central maintenance management system within 24 hours of completion.

2 Retain thermal profile data for minimum 12 months.

3 Maintain calibration records for 24 months from date of service.

4 Generate monthly compliance reports for quality assurance review.

8. PROPRIETARY INFORMATION

1 This document contains confidential and proprietary information of Polar Dynamics Robotics, Inc. and may not be reproduced or disclosed without prior written authorization.

2 All technical specifications, procedures, and protocols described herein are protected under U.S. Patents 11,234,567 and 11,345,678.

APPROVAL AND REVISION

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