COLLABORATIVE ROBOT SAFETY FEATURES DOCUMENTATION

Polar Dynamics Robotics, Inc.

Document No.: PDR-SF-2024-001

Effective Date: January 11, 2024

Version: 3.0

1. PURPOSE AND SCOPE

1 This documentation ("Safety Documentation") sets forth the comprehensive safety features, protocols, and compliance measures implemented in Polar Dynamics Robotics, Inc.'s ("PDR") collaborative robot systems, specifically the IceNav(TM)-enabled autonomous mobile robots designed for cold environment operations.

2 This Safety Documentation applies to all PDR Series 7000 and 8000 collaborative robots operating in temperature ranges from ambient to -40 C (-40 F).

2. DEFINITIONS

1 "Collaborative Robot" or "Cobot" means any PDR autonomous mobile robot designed to operate in shared workspaces with human operators.

2 "IceNav(TM) System" means PDR's proprietary navigation and safety control system specifically designed for cold environment operations.

3 "Safety Zone" means the designated operational area around the Cobot where specific safety protocols are activated.

3. SAFETY SYSTEM ARCHITECTURE

1 Primary Safety Systems

a) Redundant emergency stop circuits with dual-channel safety architecture

b) Multi-zone LIDAR scanning system with cold-resistant optical components

c) Force-torque sensors with temperature-compensated feedback loops

d) Proprietary IceNav(TM) proximity detection system

2 Secondary Safety Systems

a) Capacitive skin sensors with anti-icing coating

b) Thermal imaging cameras for human detection

c) Audio-visual warning systems

d) Wireless emergency stop integration

4. OPERATIONAL SAFETY FEATURES

1 Speed and Force Limitation

a) Maximum speed: 1.2 m/s in collaborative mode

b) Dynamic force limitation based on proximity detection

c) Automatic speed reduction in high-traffic zones

d) Temperature-dependent movement protocols

2 Collision Avoidance

a) Real-time path planning with 360 obstacle detection

b) Predictive collision avoidance using AI algorithms

c) Minimum separation distance maintenance: 500mm

d) Anti-slip protocols for icy conditions

5. COMPLIANCE AND CERTIFICATION

1 Safety Standards Compliance

- ISO 10218-1:2011
- ISO/TS 15066:2016
- ANSI/RIA R15.06-2012
- EN ISO 13849-1:2015 (PLd, Category 3)

2 Environmental Standards

- IP65 rating for cold environment operation
- IEC 60068-2-1 (Cold conditions testing)
- UL 1740 certification

6. RISK ASSESSMENT AND MITIGATION

1 Systematic Risk Analysis

a) HAZOP analysis for cold environment operations

b) FMEA documentation for critical components

c) Regular safety performance reviews

d) Environmental condition monitoring

2 Safety Protocols

a) Automatic system shutdown at -45 C

b) Emergency operation procedures

c) Safety zone recalibration protocols

d) Human-robot interaction guidelines

7. MAINTENANCE AND INSPECTION

1 Regular maintenance requirements:

- Daily system checks
- Weekly sensor calibration
- Monthly safety system verification
- Quarterly comprehensive inspection

2 Documentation Requirements

- Maintenance logs
- Incident reports
- Safety system modifications
- Calibration records

8. DISCLAIMER AND LIMITATIONS

1 This Safety Documentation is confidential and proprietary to PDR.

2 Compliance with this documentation does not guarantee absolute safety and must be implemented in conjunction with facility-specific safety protocols.

3 PDR reserves the right to modify this documentation as required by technological advances or regulatory requirements.

9. CERTIFICATION

The undersigned hereby certifies that this Safety Documentation has been reviewed and approved by PDR's Safety Review Board.

POLAR DYNAMICS ROBOTICS, INC.

By:

Dr. James Barrett

Chief Robotics Officer

Date: January 11, 2024

By:

Sarah Nordstrom

Chief Operating Officer

Date: January 11, 2024

10. REVISION HISTORY

Version 3.0 - January 11, 2024

- Updated IceNav(TM) safety protocols
- Added temperature-dependent movement protocols
- Revised maintenance schedules

Version 2.1 - June 15, 2023

Version 2.0 - January 20, 2023

Version 1.0 - March 30, 2022

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