13849 SAFETY COMPLIANCE DOCUMENTATION - COLD ENVIRONMENT SER

ISO 13849 SAFETY COMPLIANCE DOCUMEN

Document Reference: PDR-ISO-13849-CE-2023-V1.2

Effective Date: January 11, 2024

Document Owner: Polar Dynamics Robotics, Inc.

1. PURPOSE AND SCOPE

1. This documentation certifies that the Polar Dynamics Robotics Cold

2. This certification covers all CE Series AMRs manufactured after Ja

2. SAFETY FUNCTION CLASSIFICATIONS

1. **Performance Level (PL) Assignments**

-

Emergency Stop System: Performance Level e (PLe)

-

Safety-rated Monitored Stop: Performance Level d (PLd)

-

Speed and Separation Monitoring: Performance Level d (PLd)

-

Temperature-compensated Motion Control: Performance Level c (PLc

2. **Category Classifications**

-

Primary Safety Functions: Category 3 architecture

Environmental Monitoring Systems: Category 2 architecture

-

Peripheral Safety Functions: Category B architecture

3. TECHNICAL SAFETY REQUIREMENTS

1. **Cold Environment Specific Requirements**

-

Operating temperature range: -40 C to +5 C

-

Thermal shock resistance: Rate of change 20 C per hour

-

Ice accumulation tolerance: Up to 2mm surface ice

-

Condensation protection: IP65 rated enclosures

2. **Safety-Critical Components**

-

Redundant temperature-hardened sensors

-

Dual-channel safety controllers with cross-monitoring

-

Cold-rated emergency stop circuits with supervised outputs

-

Temperature-compensated braking systems

4. RISK ASSESSMENT AND MITIGATION

1. **Identified Hazards**

- Low-temperature material embrittlement
- Sensor performance degradation
- Battery capacity reduction
- Condensation-related electrical risks
- Ice accumulation on critical surfaces

2. **Control Measures**

- Automated environmental condition monitoring
-

Real-time performance degradation detection

-

Predictive maintenance scheduling

-

Fault-tolerant operation modes

-

Graceful performance degradation protocols

5. VALIDATION AND TESTING

1. **Test Protocols**

-

1000-hour continuous operation at -30 C

-

Thermal cycling: 100 cycles (-40 C to +25 C)

- Emergency stop functionality at temperature extremes
- Sensor accuracy verification in icing conditions

2. **Validation Results**

- Mean Time Between Dangerous Failures (MTTFd): >100 years
- Diagnostic Coverage (DC): 98%
- Common Cause Failure (CCF) score: 75
- System Probability of Dangerous Failure per Hour (PFHd): <10^-8

6. DOCUMENTATION AND RECORDS

1. **Required Documentation**

-

Safety requirement specifications

-

SISTEMA calculations and reports

-

Component certificates and declarations

-

Test reports and validation records

-

Technical construction files

2. **Record Retention**

All safety-related documentation shall be maintained for a minimum o

from the date of manufacture of the last unit of each model series.

7. COMPLIANCE DECLARATION

Polar Dynamics Robotics, Inc. hereby declares that the CE Series AM

with all relevant requirements of ISO 13849-1:2015 and ISO 13849-2:

operated within specified parameters and maintained according to pre

procedures.

8. AUTHORIZATION

This documentation is authorized by:

/s/ Dr. James Barrett

_

Dr. James Barrett

Chief Robotics Officer

Polar Dynamics Robotics, Inc.

Date: January 11, 2024

/s/ Marcus Chen

Marcus Chen

Chief Technology Officer

Polar Dynamics Robotics, Inc.

Date: January 11, 2024

9. LEGAL DISCLAIMER