LOW-TEMPERATURE ELECTRONICS VALIDATION REPORT

LOW-TEMPERATURE ELECTRONICS VALID

Polar Dynamics Robotics, Inc.

Report Date: January 11, 2024

Document Reference: PDR-TECH-2024-011

1. EXECUTIVE SUMMARY

This validation report documents the comprehensive testing and perfo
verification of Polar Dynamics Robotics' BlueCore(TM) electronic syst
extreme low-temperature conditions. Testing was conducted between

2023, and December 31, 2023, at our ISO/IEC 17025-certified testing

Rochester, Minnesota.

2. SCOPE OF VALIDATION

1. Systems Tested

-

BlueCore(TM) Navigation Control Unit (NCU) v4.2

-

Temperature-Hardened Motor Controllers (THMC-Series)

-

Cold-Environment Sensor Array (CESA) Platform

-

Reinforced Power Distribution Modules (RPDM)

2. Testing Parameters

-

Temperature Range: +20 C to -40 C

-

Humidity Range: 15% to 85% RH

-

Duration: 500 operational hours per unit

-

Sample Size: 15 units per component category

3. TESTING METHODOLOGY

1. Environmental Chamber Specifications

-

Manufacturer: Thermotron Industries

Model: SE-2000-15-15

-

Calibration Date: September 30, 2023

-

Chamber Volume: 2000L

-

Temperature Stability: 0.1 C

2. Test Protocols

-

MIL-STD-810H, Method 502.7 (Low Temperature)

-

IEC 60068-2-1 (Cold Test)

-

4. PERFORMANCE RESULTS

1. BlueCore(TM) NCU Performance

- Start-up Success Rate: 99.8% at -40 C
- Navigation Accuracy Deviation: <0.5% from baseline
- Power Consumption: Within 112% of room temperature specifications
- Mean Time Between Failures (MTBF): 8,750 hours at -30 C

2. Motor Controller Performance

- Torque Consistency: 98.5% maintained at -35 C
- Response Time: <15ms at all tested temperatures
- Current Draw Variation: +8% maximum at -40 C
- Thermal Protection Activation: 0 false positives

3. Sensor Array Results

- Detection Range: 99.2% of rated performance
- False Reading Rate: <0.1% at all temperatures
-

Calibration Drift: <1% over 500 hours

-

Signal-to-Noise Ratio: >45dB maintained

5. COMPLIANCE VERIFICATION

1. Industry Standards Met

-

ISO 13849-1:2015 (Performance Level D)

-

IEC 61508-1:2010 (SIL 2)

-

ANSI/RIA R15.06-2012

-

CE Marking Requirements (2014/30/EU)

2. Regulatory Conformance

- FDA 21 CFR Part 11 (where applicable)
- OSHA 29 CFR 1910.212
- UL 1740 Requirements
- CSA-C22.2 No. 73

6. VALIDATION CONCLUSIONS

1. Primary Findings

The BlueCore(TM) electronic systems have demonstrated consistent within specified parameters across all tested temperature ranges. Key

exceed minimum requirements for industrial cold-storage deployment

2. Performance Certification

Based on comprehensive testing results, the systems are certified for
in temperature-controlled environments down to -40 C with a safety m
C.

7. RECOMMENDATIONS

1. Operational Guidelines

-

Implement 15-minute warm-up procedure below -35 C

-

Maintain humidity controls within specified ranges

-

Schedule preventive maintenance at 2000-hour intervals

-

Monitor power supply voltage stability

2. Risk Mitigation

-

Install temperature monitoring beacons every 50 meters

-

Implement automated shutdown protocols below -42 C

-

Maintain backup power systems at 100% charge

-

Conduct monthly sensor calibration checks

8. CERTIFICATION

This validation report certifies that the tested systems meet or exceed specified performance requirements for low-temperature operation in environments.

9. AUTHENTICATION

Prepared by:

Dr. Marcus Chen

Chief Technology Officer

Polar Dynamics Robotics, Inc.

Verified by:

Dr. Sarah Thompson

Lead Validation Engineer

Certificate #: VE-2023-8842

Approved by: 11

Victoria Wells

Quality Assurance Director

ISO 9001:2015 Lead Auditor

10. LEGAL DISCLAIMER

This report contains confidential and proprietary information belonging
Dynamics Robotics, Inc. The validation results presented are based o
test conditions and may vary in actual deployment environments. This
not constitute a warranty of any kind, either express or implied. Polar
Robotics, Inc. reserves the right to modify specifications without notice

Document Control: PDR-TECH-2024-011-R1

Classification: Confidential

Retention Period: 7 years