

PDR-TS-445 THERMAL MANAGEMENT SYSTEM DESIGN

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Technical Design Specification and Requirements Document

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1. DOCUMENT CONTROL

1.1 Proprietary Notice

This document contains confidential and proprietary information belonging to Polar Dynamics Robotics, Inc. ("Company"). Any unauthorized use, reproduction, or distribution is strictly prohibited.

1.2 Version Control

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Original Release: March 10, 2023

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Document Owner: Technical Systems Division

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Technical Approval: Dr. James Barrett, Chief Robotics Officer

2. SYSTEM OVERVIEW

2.1 Purpose

This document specifies the design requirements and technical specifications for the BlueCore(TM) Thermal Management System (TMS) implemented in Autonomous Mobile Robots operating in sub-zero environments.

2.2 Scope

These specifications govern all thermal management components and systems integrated into production units designated for operation in environments ranging from -40 C to +25 C.

3. TECHNICAL SPECIFICATIONS

3.1 Operating Parameters

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Primary Operating Range: -40 C to +25 C

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Maximum Thermal Load: 2.8 kW

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Thermal Response Time: 180 seconds

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System Power Draw: 450W nominal, 750W peak

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Thermal Efficiency Rating: 92%

3.2 Core Components

Primary Heat Exchange Unit (HEU-450)

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Dual-phase cooling circuit

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Variable-flow coolant distribution system

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Proprietary cold-resistant coolant mixture (Patent #US10,789,456)

Thermal Control Module (TCM-X2)

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Adaptive thermal load balancing

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Real-time temperature monitoring

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Predictive thermal management algorithms

4. DESIGN REQUIREMENTS

4.1 Mechanical Integration

All thermal management components must maintain IP67 rating

Maximum system weight: 42 kg fully loaded

Form factor must conform to Series X-450 chassis specifications

Serviceability requirements per ISO 9001:2015 standards

4.2 Safety Requirements

Emergency thermal shutdown capability within 3 seconds

Redundant temperature monitoring systems

Compliance with ANSI/RIA R15.06-2012 safety standards

Fault detection and reporting system with 99.99% reliability

5. PERFORMANCE CRITERIA

5.1 Thermal Management

Maintain internal operating temperature of 15 C \pm 2 C

Maximum temperature gradient across critical components: 5 C

Thermal stabilization time from cold start: 5 minutes

Heat dissipation capacity: 3000W continuous

5.2 Reliability Metrics

Mean Time Between Failures (MTBF): 50,000 hours

Service interval: 2,000 operating hours

Component lifetime: 5 years minimum

Thermal cycle endurance: 10,000 cycles

6. COMPLIANCE AND CERTIFICATION

6.1 Required Standards

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UL 1995 Heating and Cooling Equipment

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IEC 60204-1 Safety of Machinery

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ISO 13849-1 Safety of Control Systems

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CE Marking requirements for European markets

6.2 Testing Requirements

Environmental stress screening per MIL-STD-810H

Thermal performance validation per ASHRAE 37-2009

EMC compliance testing per IEC 61000-6-2

Safety certification per UL 1995

7. INTELLECTUAL PROPERTY

7.1 Proprietary Technology

This design specification incorporates proprietary technology protected by Patents #10,789,456, #10,892,344, and #11,023,567, and other pending applications.

7.2 Confidentiality

All design elements, technical specifications, and performance criteria contained herein are classified as Trade Secrets under applicable state and federal law.

8. APPROVAL AND AUTHORIZATION

The undersigned hereby approve this Technical Design Specification:

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Dr. James Barrett

Chief Robotics Officer

Date: January 15, 2024

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Marcus Chen

Chief Technology Officer

Date: January 15, 2024

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Sarah Nordstrom

Chief Operating Officer

Date: January 15, 2024

9. REVISION HISTORY

Version 2.3 - January 15, 2024

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Updated thermal response specifications

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Added new safety compliance requirements

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Revised component lifetime metrics

Version 2.2 - October 1, 2023

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Modified operating temperature range

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Updated certification requirements

Version 2.1 - June 15, 2023

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Enhanced performance criteria

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Added new test protocols

Version 2.0 - March 10, 2023

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Initial release of revised specification

