Software Requirements Specification (SRS) for Group Control for 150kW Direct Liquid Cooling System (DLC)

System Name: DLC Group Control System (DLC-GCS)

Module: Group Automatic Control

Version: 1.0

Date: November 25, 2025

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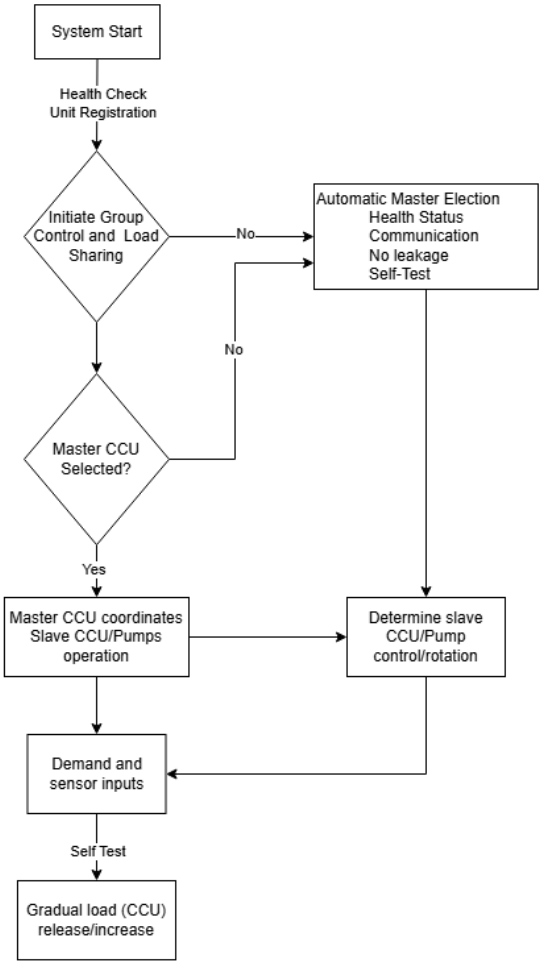
1. Introduction

Automatic Group Control



1.1 Purpose

This SRS describes the software requirements for **Group Control** of multiple **150kW Direct Liquid Cooling (DLC)** systems The Group Control feature enables coordinated management of multiple coolant control units (CCUs), optimizing cooling distribution, balancing pump runtime, and ensuring system redundancy for high-density compute racks.

1.2 Scope

The Software will:

Control multiple CCUs as one group. Optimize coolant distribution between units. Share load based on available capacity, temperature demand, and pump performance. Provide redundancy (fail-over) if any CCU fails. Synchronize alarms, monitoring, and control through centralized HMI/Web UI.

1.3 Scope

Each unit includes:

3 Pumps

Temperature, Pressure and Flow Sensors

Leak Detection Sensor

Communication Interface

Local CCU Controller

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2. System Architecture

2.1 Group Composition

Components	Quantity
DLC CCU Units	2- 10 Units
Group Controller	1 (Software-based central logic)
HMI/Web Interface	1 shared view
Communication Bus	Ethernet/TCP/IP, Modbus TCP

2.2 Inputs

Inputs are all the data or signals received by the Group Controller so it can make decisions, the information the software receives

Source	Inputs
CCUs	Pump status, sensor data, unit availability
Sensors	Temperature, Pressure, Flow and Level
User Interface	Mode, Setpoints, Capacity scheduling

Purpose: The group controller needs this information to decide **how many units must run, how much each should load, and when to isolate a faulty unit.**

2.3 Outputs

Outputs are the actions or commands sent by the Group Controller to the CCUs or to the user interface.

Output	Function
CCU Commands	Start/stop pumps, load distribution
Alarms	Centralized alarm handling
Data logging	Group performance and history

Purpose: Outputs make the system take action (control pumps, alarms, isolate units) and keep humans informed.

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3. Functional requirement

3.1 Group Load Sharing

The DLC Group Controller shall calculate total system cooling demand. The controller shall assign cooling loads proportionally to available CCUs. Load distribution algorithm must consider

Temperature delta (In - Out)

Flow availability

Pump runtime balance

Unit health status

Formula Example

Unit Load Share $\propto$ Available Flow x Temperature Demand x Unit Health Score

3.2 Group Redundancy and Failover

If one unit fails:

Remaining CCUs shall redistribute load automatically.

If redundancy is insufficient:

System issues **Group Capacity Warning.**

Critical conditions trigger **Group Safe Mode**

Failover Actions:

Conditions	**Action**
Pump/CCU Failure	Shift load to remaining CCUs
Leak in Unit	Isolate unit, Raise an alarm (Let customer decide to stop the unit or not manually)
Low Level	Raise an alarm. Switch unit to standby, remove from group or let customer decide if to remove.

3.3 Group Startup Logic

1.) Validate availability of at least **N+1 units** (where N is required capacity).
2.) Each CCU performs local self-test.
3.) Group controller selects **Lead Units** based on:
Runtime hours (rotation priority)
Condition score (temperature, pressure, sensor status)

Startup Sequence:

Standby → Health Check → Unit Registration → Group Start → Load Assignment

3.4 Group Shoutdown

Gradual load release:

Selected units switch to standby first.

Lead unit remains last.

Emergency Shutdown:

All units stop in case of global leak, overpressure, or command from operator.

3.5 Pump Rotation Across Group

Group controller shall rotate pump priority weekly between units.

Rotation based on **runtime equalization** and **sensor health condition**.

3.6 Central Alarm and Event Management

Alarm Type	Source	Action
Local Alarms	Single CCU	Isolate unit, redistribute load
Group Alarms	Demand > Capacity, Global Fault	Notify User + Safe mode
Critical	Leak, Overpressure	Raise an alarm to shutdown the unit (Decision to shutdown to be made by an operator)

3.7 Data Logging and Reporting

All alarms, warnings and events (Local and Group) should be logged.

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4. User Interface Requirements

4.1 Central Display

Must show:

Real time load per unit (%)

Pump status of all units

Group alarms and health score

Combined capacity and demand

4.2 User Controls

Function	Allowed
Start/Stop Group	Yes
Force Unit Offline	Yes
Adjust Load Priority	Yes

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5. Communication Requirements

Protocol: Modbus TCP

6. Concept

6.1 How should Group Control decide pump operation?

In Group Control, we have multiple CCUs, each with:

3 pumps (P1, P2, P3)

Sensors (Temperature, Pressure, Flow and Leakage)

Automatic load-based cooling

Group Control should assign pumps based on the below rule

Master-Slave Mode

One CCU is master, rest are slaves. Master decides which CCU to run or which pump runs in all CCUs (Master controlling each pump could be complex)

6.2 Master-Slave Group Control Mode

So the Master CCU will coordinate CCU/pump operation for all CCUs in the 150kW Direct Liquid Cooling system. Master commands and the slaves execute pump control/rotation based on sensor inputs and heat load.

6.3 How is Master CCU Selected?

Rule for choosing master

1.) **Automatic Master Election**
Each CCU can become Master
Master is elected based on:
a.) Health Status
b.) Communication availability
c.) No internal leakage/fault

2.) **Highest Availability Priority**
CCU with best parameters becomes Master:
Lower temperature rise
Best flow
Lowest runtime hours

No/Minimum fault

Each CCU can become master based on communication availability, no leakage/Minimum fault and successful internal self-test.

6.4 Load Sharing Rule Between CCUs

How cooling load is shared between CCUs?

- Demand-based scaling (Min. pumps until demand rises)
- Temperature priority (highest coolant temperature gets priority)

6.5 Detailed Control Logic

Master selection algorithm

System start sequence

CCU/Pump start/stop rules

Load growth scaling rules

CCU/Pump priority rotation logic

Slave execution rules

Master override logic

6.6 Alarm and Event Logging

Fault classification (Minor/Major/Critical)

Alarms and warnings (Global/Local)

Master change events

6.7 Web and User HMI Requirement

Live CCU group status

Master/Slave Indication