Technical Proposal – NARADA BESS System

Project Name: Boulouparis 50MW 150MWh BESS

Project Location: Caledonia

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Zhejiang Narada Power Source Co., Ltd

Content

I. Abbreviations

1	AC	Alternating Current
2	BAT	Battery
3	BCP	Battery Connection Panel
4	BESS	Battery Energy Storage System
5	BOS	Balance of System
6	BMS	Battery Management System
7	BMU	Battery Management Unit
8	BCU	Battery Cluster Management Unit
9	BAMS	Battery Administration Management System
10	BAU	Battery Administration Management Unit
11	BOP	Balance of Plant
12	BOL	Beginning of Life
13	DC	Direct Current
14	EMS	Energy Management System
15	EOL	End of Life
16	FSS	Fire Suppression System
17	HMI	Human Machine Interface
18	HV	High Voltage
19	HVAC	Heating & Ventilation and Air Conditioning
20	LFP	Lithium iron phosphate
21	MV	Middle Voltage
22	PCS	Power Conversion System
23	POC	Point of Connection
24	SOC	State of Charge
25	SOH	State of Health
26	UPS	Uninterruptable Power Supply

II. Overview

Narada Power Source is established in 1994, one of the most famous batteries and battery storage system manufacture in China in many industrial sectors, like renewable energy, telecom and data center infrastructure, e-mobility etc., with around 12 billion RMB turnover in 2022 and installed capacity of over 5GWh worldwide till middle of 2023.

Narada manufactures LFP battery cell to build BESS system solution. Below is Narada's product portfolio for different applications, including 2C, 1C and less than 0.5C-rate applications.

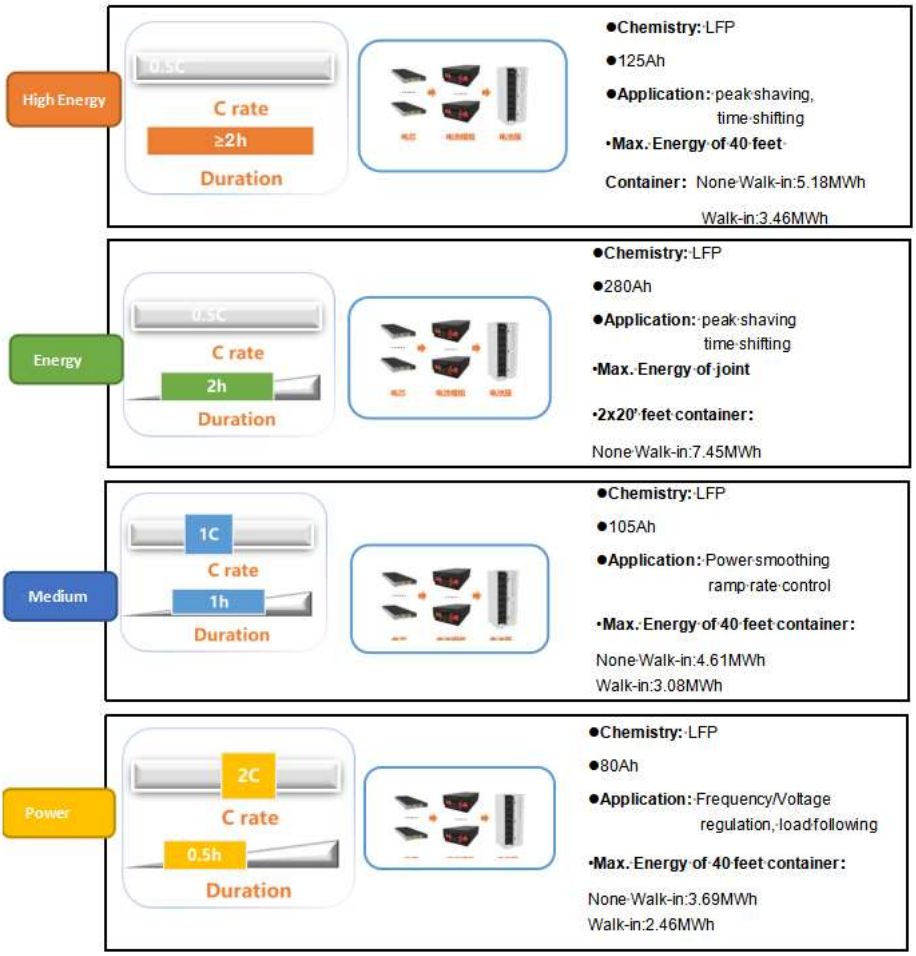

Fig. 2-1: Narada's Product Portfolio

III. Customer Requirements

3.1 BESS System Requirement

1) System size (power/capacity): 50MW/150MWh @AC side
2) System application: BESS
3) Cycle number: 365 cycles per year
4) Requirement of EOL: 20 years

3.2 Scope of Supply

We will offer proposals for the requirements as below:

1) Storage batteries;
2) Battery installation rack;
3) BMS;
4) HVAC;
5) Fire suppression system;
6) Container solution;

IV. Technical Proposal

4.1 BESS Configuration

Table 4-1: BESS Configuration

Items		Unit	Value
System Specification	Required Power at D.C.	MW	58.09
	Required Energy at D.C.	MWh	158.71
	Battery Factor	%	98.00%
Battery System	Module Type		166.4NESP280
	Module Capacity	Ah	280
	Module Voltage	V	166.4
	Modules Per Rack	pcs	8
	Rack Rated Voltage	V	1331.2
	Rack Minimum Voltage	V	1164.8
	Rack Maximum Voltage	V	1497.6
	Energy Per Rack	MWh	0.37
	Total Battery Rack	Strings	600
	Battery No	pcs	4800
	Nominal Installed Energy	MWh	223.64
	Usable Energy in FAT	MWh	219.17
	Usable Energy in SAT	MWh	212.46
BMS	Battery Management System	set	600
Rack	Battery Cabinet	set	600
Battery Container	Container Size	ft	20
	Install Rack No per Container	set	10
	Install Energy per Container	MWh	3.73
	No of Container or outdoor cabinet (F90 Fire Retard)	set	60
	Fire Protection System	set	30
	DC Combiner Cabinet	set	60
	Liquid-cooled system	set	60
	Liquid-cooled system	kW	40
	Auxiliary Electrics	set	60

4.2 System Equipment List

Table 4-2: List of Supply Scope

Equipment	Specification and Models	Unit	Quantity	Remark
Battery Module	166.4NESP280	pcs	4800	
Battery Strings	1331.2V280Ah system	set	600	With racks and BMS
Container	20ft ISO container	set	60	Battery container
FSS	NOVEC1230	Set	30	
DC Cabinet	With fuse protection	Unit	60	Battery Connection Panel
Liquid Unit	40kW cooling capacity	Unit	60	
AC/DC Cabinet	Power distribution box	Unit	60	

4.3 Auxiliary Consumption Table

Table 4-4: Auxiliary Consumption Table

Items	System	Description	Power(w)	No	Operation mode and type	Simultaneous factor	Total Power /W	Remark
1	Liquid Cooling Unit	Liquid Cooling Unit	23100	60	I often, continuously	0.70	970200	Maximum operating power
		Liquid Cooling Unit	900	60	I often, continuously	1.00	54000	Standby input power
2	Container auxiliary power	lighting	48	60	III Infrequent and short	0.30	864	Maximum operating/standy power
		Container socket	2000	120	III Infrequent and short	1.00	240000	
		switch	50	30	I Infrequent and continuously	0.50	750	
3	BMS	Operating	200	600	I often, continuously	1.00	120000	Maximum operating power
		Standy by	80	600	I often, continuously	0.30	14400	Standby input power
4	FSS	Liquid cooling valve（spare）	40	240	I Infrequent and continuously	0.10	960	Maximum operating/standy power
		Hydrogen fan	50	240	I Infrequent and continuously	0.10	1200	
		Fire proof valve	35	4	I Infrequent and	0.10	14	

					continuously			
		Gas detector	0.6	120	I Infrequent and continuously	0.10	7.2	
		Gas fire extinguishing controller	352	30	I Infrequent and continuously	0.30	3168	
		Indoor sound and light alarm	1.5	30	I Infrequent and continuously	0.10	4.5	
		Outdoor sound and light alarm	1.5	30	I Infrequent and continuously	0.10	4.5	
		Temperature detector	0.002	240	I Infrequent and continuously	0.10	0.048	
		Smoke detector	0.002	240	I Infrequent and continuously	0.10	0.048	
		Extinguishant status & manual actuator	0.8	30	I Infrequent and continuously	0.10	2.4	
		indicator light	4.8	30	I Infrequent and continuously	0.10	14.4	
		Abort Switch	0.8	30	I Infrequent and continuously	0.10	2.4	
In total:							Operating power (Kw)	1337.191496
							Standby power (Kw)	71.568

v. Battery System Design

This system adopts the outdoor container BESS system, which contains Narada LFP battery: NESP series, intelligent battery management system and the group technology. We can supply safe, reliable, stable power supply solutions, to provide comprehensive

highly quality energy.

The BESS communication single layout drawing shows the design of BESS and how the AC, DC, and control sections are interconnected. In DC section, one battery bank is made up with certain number of racks in accordance with the PCS configuration and the banks connect to a PCS module. Several combinations of PCS and battery banks establish BESS.

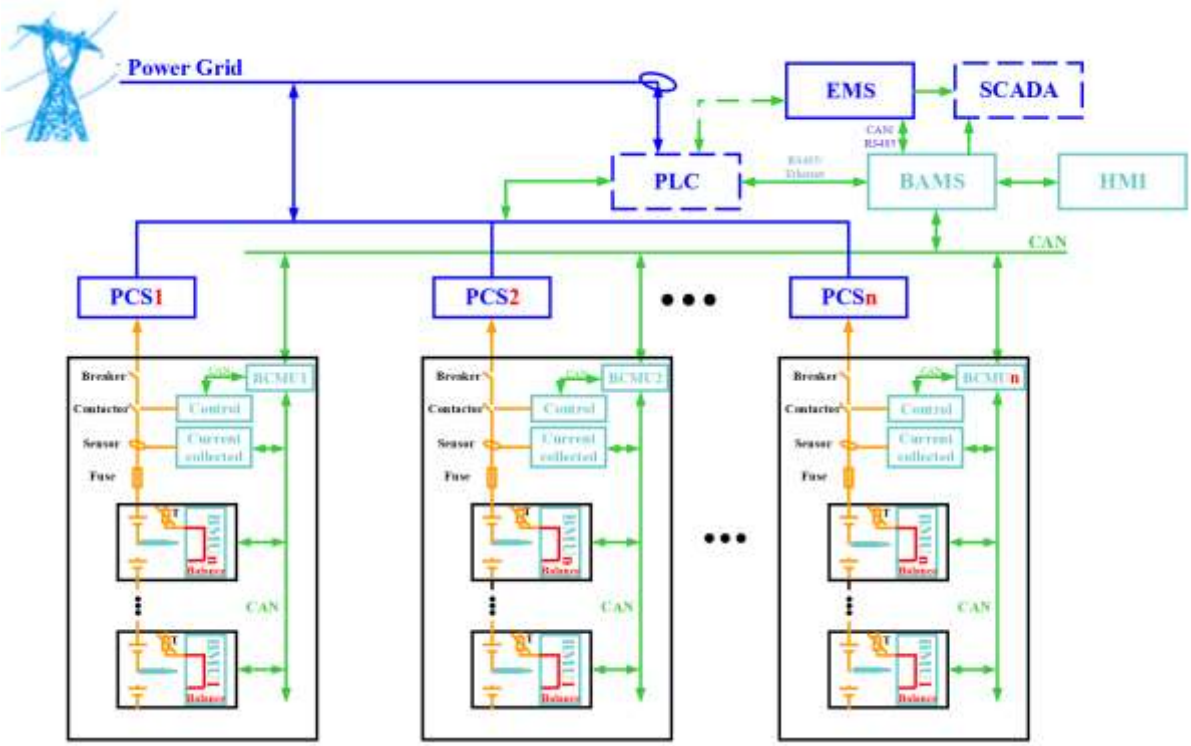

Fig. 5-1: BESS Communication Single Layout Drawing (For reference)

5.1 Battery Cell

Battery cell, the basic unit of lithium iron phosphate battery, consists of positive, negative electrodes and electrolyte, with rated voltage of 3.2V and rated capacity of 280Ah. Narada adopts advanced LFP chemistry batteries, enjoying low cost, high efficiency and reliability as well as industry-leading safety technology. The battery cell is sealed in aluminum enclosure as shows in the following picture.

Table 5-1: Specification of Battery Cell

Item	UNIT	SPECIFICATION	RENDERING

Battery Chemistry	-	LFP	
Nominal Capacity	Ah	280Ah	
Nominal Energy	Wh	896	
Nominal Voltage	Vdc	3.2	
Operating Voltage	Vdc	2.50~3.65	
Dimension (W×D×H)	mm	174*72*207	
Weight	kg	5.5	
Recommended C-Rate	C	0.5	
Certificate	-	UL9540A, IEC62619, UN38.3	

5.2 Battery Module

A battery module consists of a number of cells in a manner of 1P52S, with rated voltage of 166.4V and rated capacity of 280Ah. The battery module and BMS adopt unified standard modular design to ensure the universality of the system. Flexible configuration, multiple battery modules can be in serial for expanding voltage and capacity. Battery modules are independently designed for easy maintenance and installation.

Table 5-2: Specification of Battery Module

Item	UNIT	SPECIFICATION	RENDERING
Type No.	-	166.4NESP280	
Module Configuration	-	1P52S	
Module Capacity	Ah	280	
Energy	kWh	46.59	
Nominal Volt	V	166.4	
Minimum Volt	V	145.6	
Maximum Volt	V	187.2	
Dimension (W×D×H)	mm	760*1150*237	
Weight	kg	340	
Recommended C-Rate	C	0.5	
Certificate	-	UL9540A, IEC62619, UN38.3	

5.3 Battery Rack

A number of modules and control box are connected in series through electrical connectors, delivers high voltage up to 1331.2V in rated voltage and 280Ah in rated capacity. Each battery rack contains 8 modules and 1 control box, which integrates BCU, disconnector, contactors, pre-charge resistor, fuses, current sensors and switching power supply.

Table 5-3: Specification of Battery Rack

Item	UNIT	SPECIFICATION	RENDERING
Type No.	-	166280373	
Rack Configuration	-	1P416S	
Module Qty	pcs	8	
Capacity	Ah	280	
Energy	kWh	372.7	
Nominal Volt	Vdc	1331.2	
Minimum Volt	V	1164.8	
Maximum Volt	V	1497.6	
Dimension (W×D×H)	mm	924*1155*2520	
Weight	kg	2570	
Recommended C-Rate	C	0.5	
Certificate	-	UL9540A, IEC62619, UN38.3	

5.4 Battery Management System

5.4.1 Overview

BMS collects, processes and stores the important information during the operation of the battery pack in real time, and exchanges the information with the external equipment to give real-time alarm and protection during the operation of the battery pack. BMS generally adopts multi-level distributed architecture design. For three-level architecture, BMS system is composed of module level BMU, rack level BCMU and bank level BAMS. The

overall control and communication diagram is shown as below:

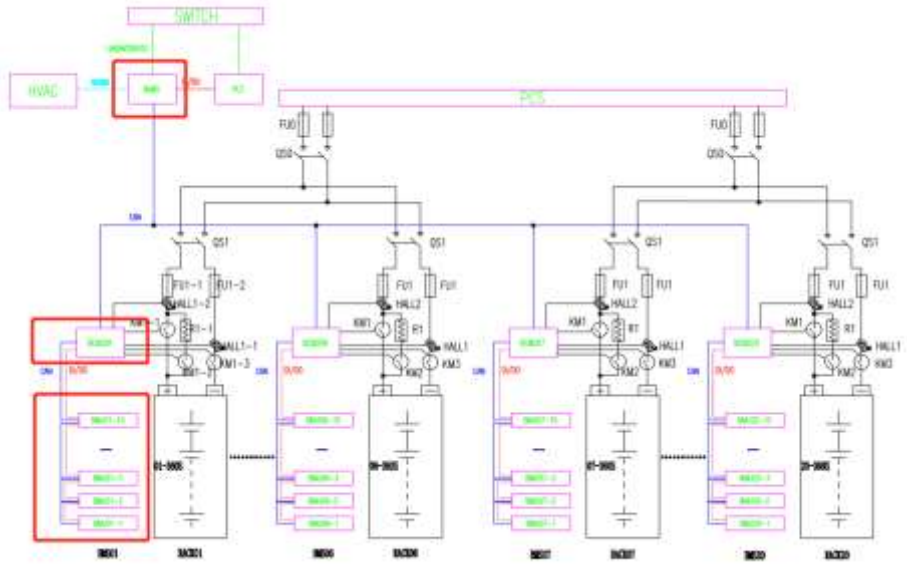

Fig. 5-2: BMS Communication Diagram (For reference)

5.4.2 Battery Multi-level BMS Function

Table 5-4: Battery Multilevel BMS Function (For reference)

BMS Tier	Main functions	Detailed functions
BMU	Basic hardware configuration	Cell voltage sampling
		Temperature sampling
	Heat management	Module fan
	Energy management	Active equalization
	Information management	Communication with BCMU
BCMU	Battery status sampling	Total rack voltage sampling
		Charging and discharging current sampling
		Insulation resistance sampling
	Thermal management	Temperature alarm signals
	Estimation of battery status	Estimation of SOC
		Estimation of SOH
	Failure diagnosis	Battery failure diagnosis alarm
		BMS system self-check and fault diagnosis alarm
	Information management	Software upgrade
		Communication with BMU and BAMS
BAMS	Information management	Remote management interface
		Communicate with PCS, EMS and other equipment
	Data storage	Data storage, transmission and processing

VI. Auxiliary System Design

6.1 Battery Connection Panel

The main function of the BCP is to combine multiple racks of batteries to one DC bus, then connect to the DC input of PCS with necessary protections. With Fuses, SPDs, and SPD fuses as key parts of battery protection devices.

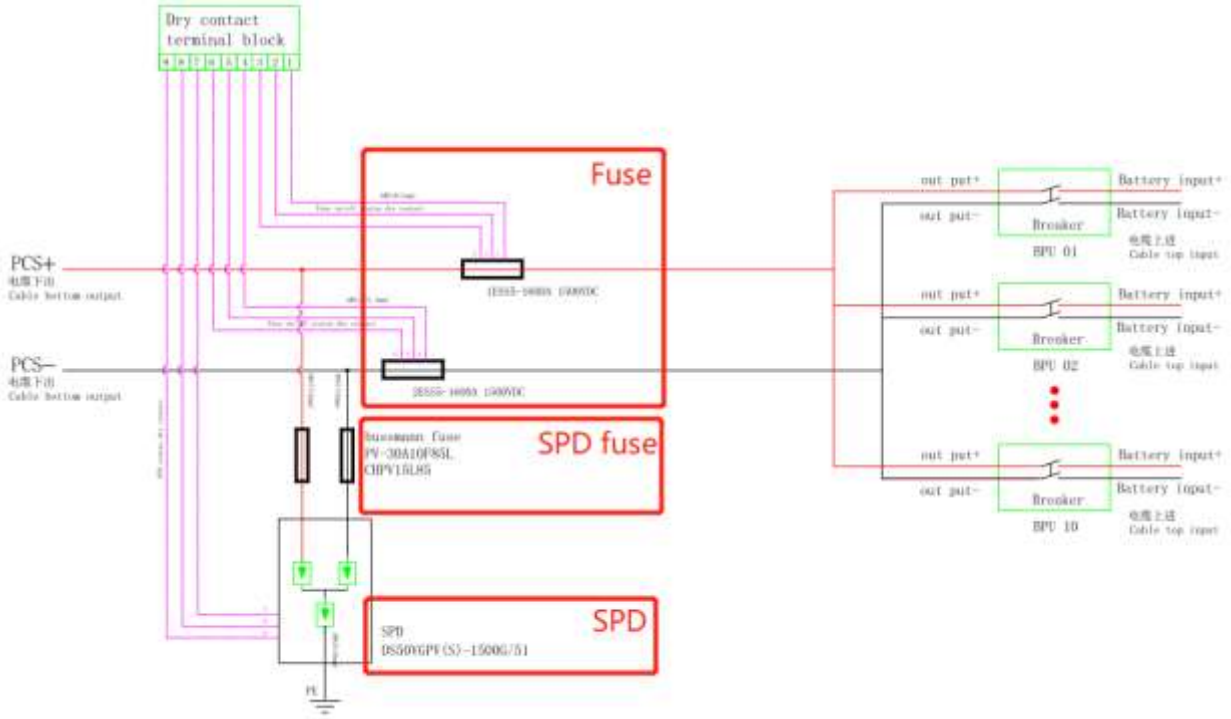

Fig. 6-1: BCP Connection Diagram (For reference)

6.2 Power Distribution Panel

Power distribution panel works as an important device for auxiliary power supply, the main functions are as follows:

1) Power source of HVAC, FFS, Lighting, BMS etc.;
2) With UPS minimum 15 minutes time as backup power supply;
3) Flexible power resource input support: 380/400/480Vac/50/60Hz 3P4L (**The type of auxiliary resource shall be confirmed by the Client before the contract**);
4) Protection function with main circuit breaker and dual E-stop circuit systems.

6.3 Thermal management System

The system uses a liquid cooling system for heat dissipation. Liquid cooling is a technology that uses a liquid as a coolant to remove heat from the heated parts. It has good temperature homogeneity. The liquid cooling system mainly consists of pipes, pumps, heat exchangers and compressors. The main coolant of the system is ethylene glycol and water.

6.3.1 Equipment Cooling Design

Inside the enclosure, there are multi-stages cooling pipes to manage the battery system. First level is the master pipe on the top of enclosure, connected with cooling unit. Second level is the secondary pipe, to separate the master pipes to each rack stage to cool down rack temperature. Third level is targeted for each module cooling (branch pipeline). Each stage will support with inlet and outlet pipes correspondingly. The coolant from master pipe to branch pipe is sent from cooling unit to modules by the pump. After absorbing the heat generated by the battery it is returned to the cooling unit. The layout of the liquid cooling pipe is shown below.

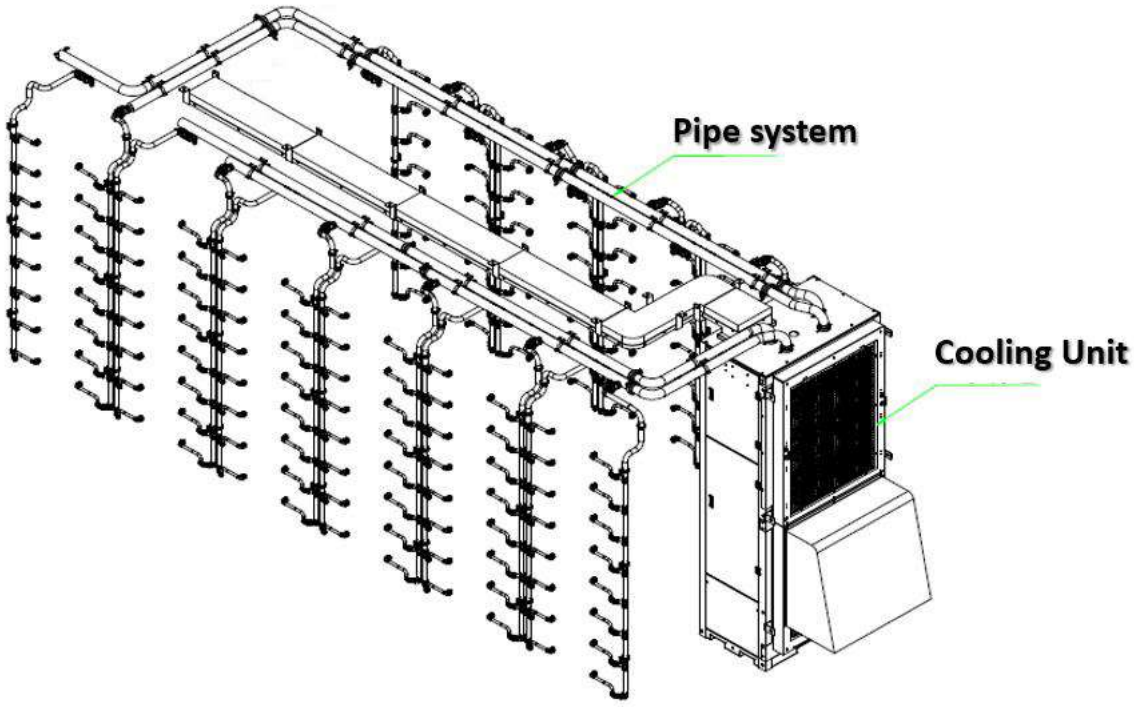

Fig. 6-2: Liquid Cooling Pipe Layout (For reference)

6.4 Fire Suppression and Alarm System Design

6.4.1 Description

The fire suppression system of battery container is composed of automatic fire alarm system, automatic gas fire extinguishing system, flammable gas detection, exhaust fan system, and sprinkler system. Automatic fire alarm and gas fire extinguishing system consists of fire alarm controller/gas extinguishing controller, temperature sensors, smoke sensors, manual/automatic switch, emergency start and stop device, sound and light alarm, alarm bell, gas release indicator, gas fire extinguishing system, pressure relief valve, etc. Flammable gas detection and exhaust system is composed of flammable gas detector and exhaust fan. The sprinkler system consists of pipes, sprinklers and joints.

Note that, this fire system design is just for reference, and should be redesigned or modified at system design stage.

6.4.2 Main Equipment List of FSS

Table 6-1: Main Equipment List of FSS

No	Components	Qty	Location	Note
1	FSS Control Panel	1	Inside	Receive detector signal, feedback system status, and linkage start gas fire extinguishing system, sound, light and exhaust equipment.
2	Smoke Sensor	8	Inside	Detect the smoke concentration in the battery container and send the alarm to the alarm controller when there is an alarm value
3	Temperature Sensor	8	Inside	Detect the ambient temperature in the battery container and sends an alarm to the alarm controller when there is an alarm value
4	Alarm Bell	1	Inside	Provide sound alarm when smoke or temperature or flammable gas alarms separately
5	Sound and Light Alarm	1	Outside	Provide sound and flash alarm when multiple alarms of smoke and temperature are given

6	FSS Emergency Start & Stop Button	1	Outside	Perform an emergency start or stop operation
7	FSS Manual/Auto Switch	1	Outside	Switch the system manually or automatically when entering the container for maintenance
8	Gas Release Indicator	1	Outside	Indicates that a gas extinguishing agent is being sprayed
9	Flammable Gas Detector	4	Inside	Detect the concentration of flammable gas in the container, send alarm signal, linkage exhaust system
10	Exhaust Fan	4	Inside	Ventilate containers to avoid deflagration caused by flammable gas accumulation
11	Gas Extinguishing System	1	Inside	Accept the start signal of the controller and spray fire extinguishing agent to protect the container with full flood extinguishing
12	Sprinkler Systems (Optional)	1	Inside	Pipes are arranged inside containers and joints are reserved outside containers for connecting fire hydrants or fire trucks to douse fires and cool them down. Manual operations are required

Note: Above quantities match to joint 20ft containers (two sets of 20ft containers).

6.4.3 Fire Suppression System Work Flow

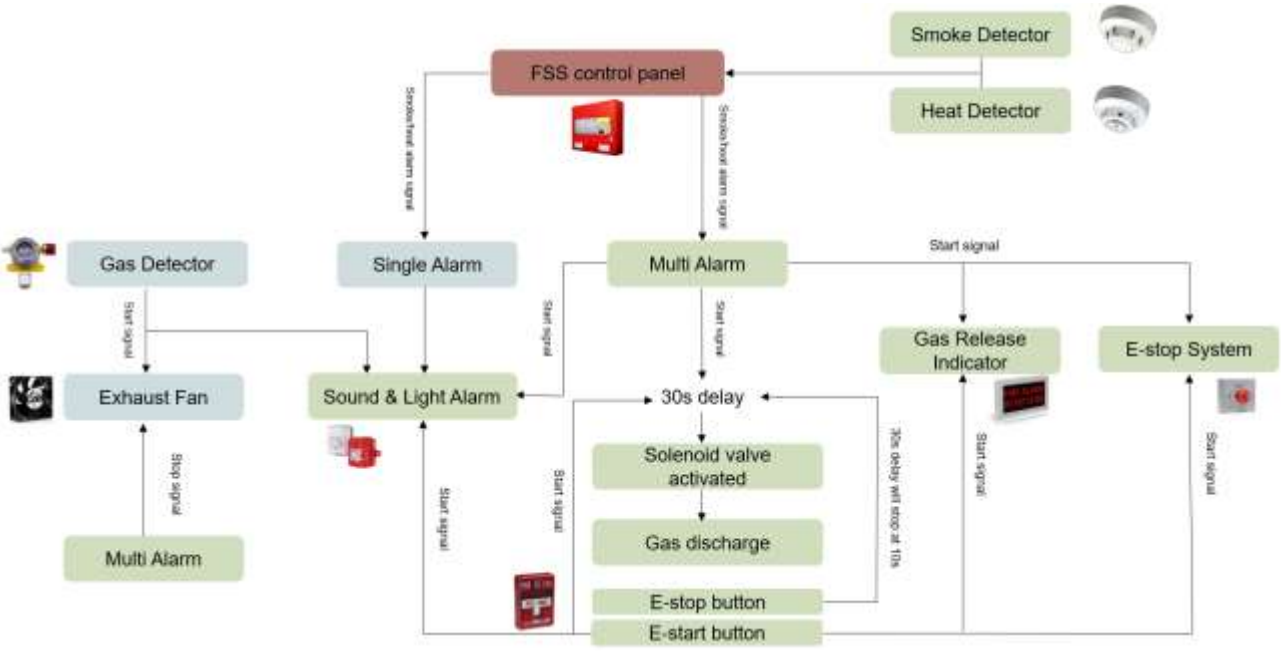

Fig. 6-3: Fire Suppression System Work Flow (For reference)

6.4.4 Control logic

6.4.4.1 Flammable Gas Detection System Work Flow

Exhaust fan will start operation if flammable gas detector detects that flammable gas concentration is higher than 20%LEL, at meanwhile “Sound & Light Alarm” will start too.

6.4.4.2 Automatic Fire Alarm System Work Flow

a. Exhaust fan will start operation if only one temperature detector or smoke sensor triggered (primary fire signal), at meanwhile “Sound & Light Alarm” will start too.

b. If two smoke sensors alarm or two temperature sensors alarm or smoke sensor (≥1) + temperature sensor (≥1) alarm (secondary fire signal), it belongs to Multi Alarm, Emergency Stop System will be tripped, exhaust fan will stop operation, “Sound & Light Alarm” and “Gas Release Indicator” will start at the same time, and 30s delay will be triggered too.

c. Once “FSS Emergency Start & Stop Button” is pushed as FSS Emergency Start, action is same as step b.

d. Once “FSS Emergency Start & Stop Button” is pushed as FSS Emergency Stop, FSS action will stop when timer runs to “10s”. If time is less than 10s, the timer will be reset to 10s and stop.

Note: The stop button cannot be released, otherwise the time will continue to countdown.

e. FSS will be discharged after 30s delay.

6.4.4.3 Manual Fire Alarm System

Fig. 6-4: FSS Control Panel Auto/Manual Switch (For reference)

When open the door, turn to “Manual Only” in the plate. When the system is at “Manual Only” state, FSS will only alarm without gas release. If need to start gas extinguishing system, push Emergency Start Button outside container door. Before close the container door, turn to “Auto & Manual”.

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