

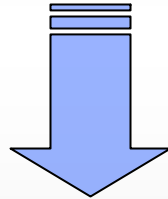
Large-sized Li-ion Battery Module for Hybrid Powered Energy System

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United Lithium Systems

Background of Development

- Increasing demand of large-scale lithium ion batteries for high power industrial applications such as hybrid powered energy systems



Development of new, large-scale lithium ion cell and battery modules which have high power, long life and superior cooling performance

Agenda

- **Cell Specifications, Technologies and Performance**
- **Battery Module Specifications and Cooling Evaluation**
- **Evaluation of Energy Efficiency for Hybrid Powered Energy System (Railway Vehicle Systems)**

LIM30H Cell Specification



Mass / kg	2.0
Dimension / mm	47W, 170L, 133H
 / in	1.85" x 6.7" x 5.2"
Nominal voltage / V	3.6
Nominal capacity / Ah	30

Key Technologies of LIM30H

- **Positive active material:**

LiMn₂O₄ improved for safety and long life

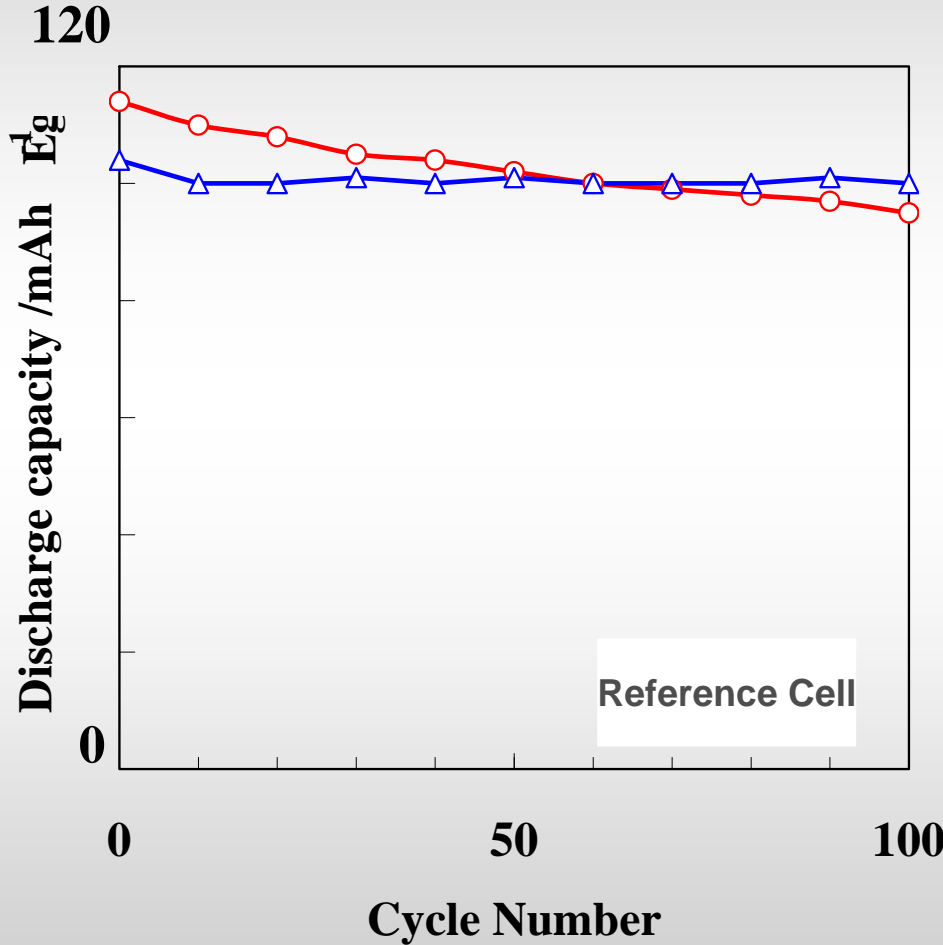
- **Negative active material:**

Hard carbon for improved high rate charge/discharge performance and high energy efficiency

- **Structure:**

Robust current collecting construction for high amperage charge/discharge

Cycle Life Performance of Improved Manganese Active Material

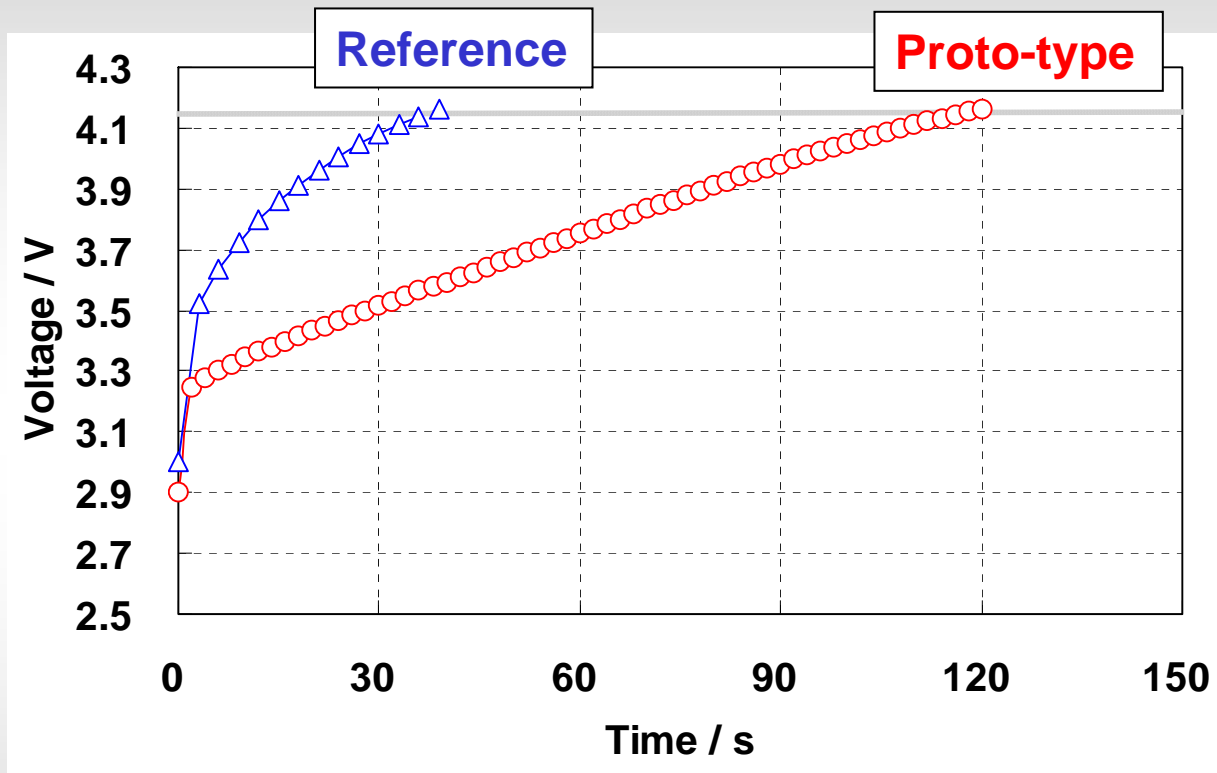


○ Previous LiMn₂O₄
△ Modified LiMn₂O₄

Charge : 1.0 mA / cm² to 4.3 V
Discharge : 2.0 mA / cm² to 3.0 V
Temperature : 60 °C
Electrolyte : Standard
Working electrode : LiMn₂O₄
Counter electrode : Li metal
Reference electrode : Li metal

Reference Cell

Quick Charge Performance of the Cells with Various Negative Active Materials



1. Proto-type cell

2. Reference cell

Charge conditions

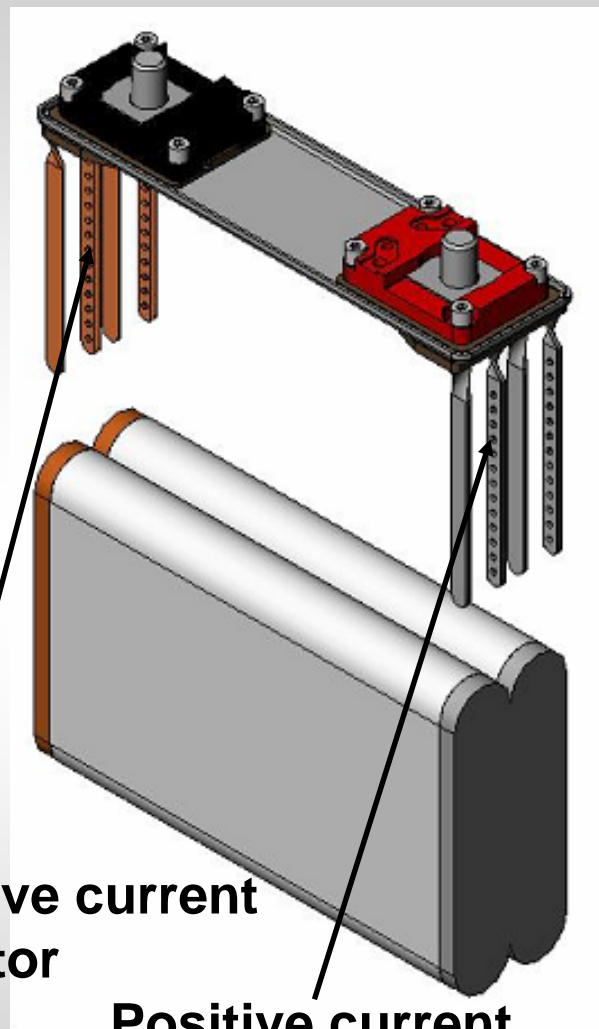
Negative active material: **Hard carbon**

Negative active material: **Graphite**

Discharge : 1CA to 2.75 V at 25°C

Charge : 10CA to 4.15 V at 25°C

Structure of LIM30H



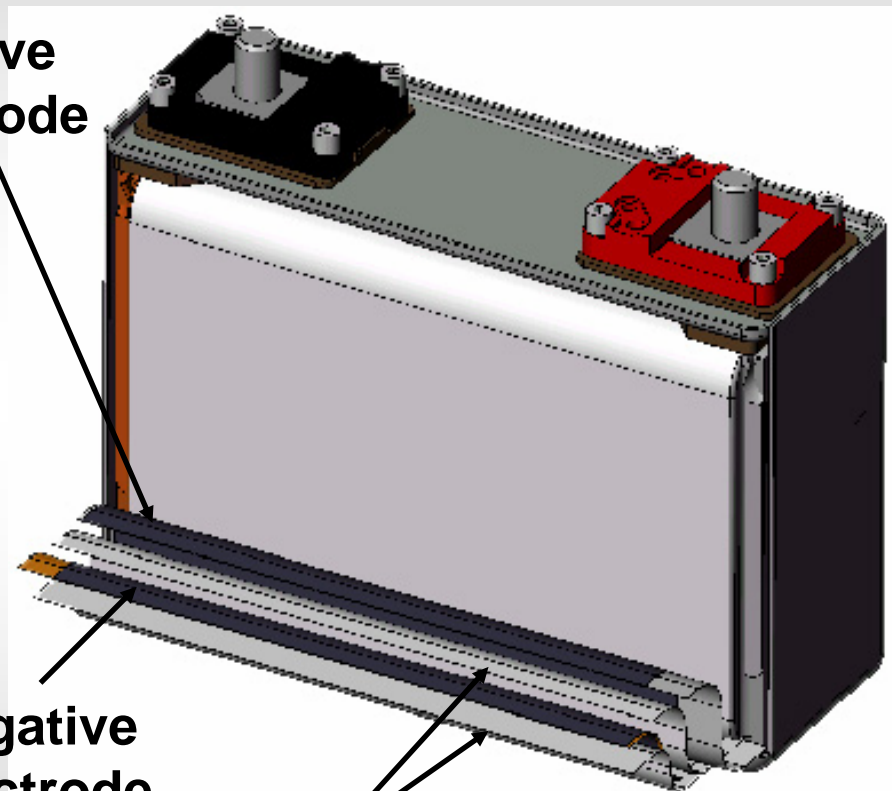
Negative current collector

Positive current collector

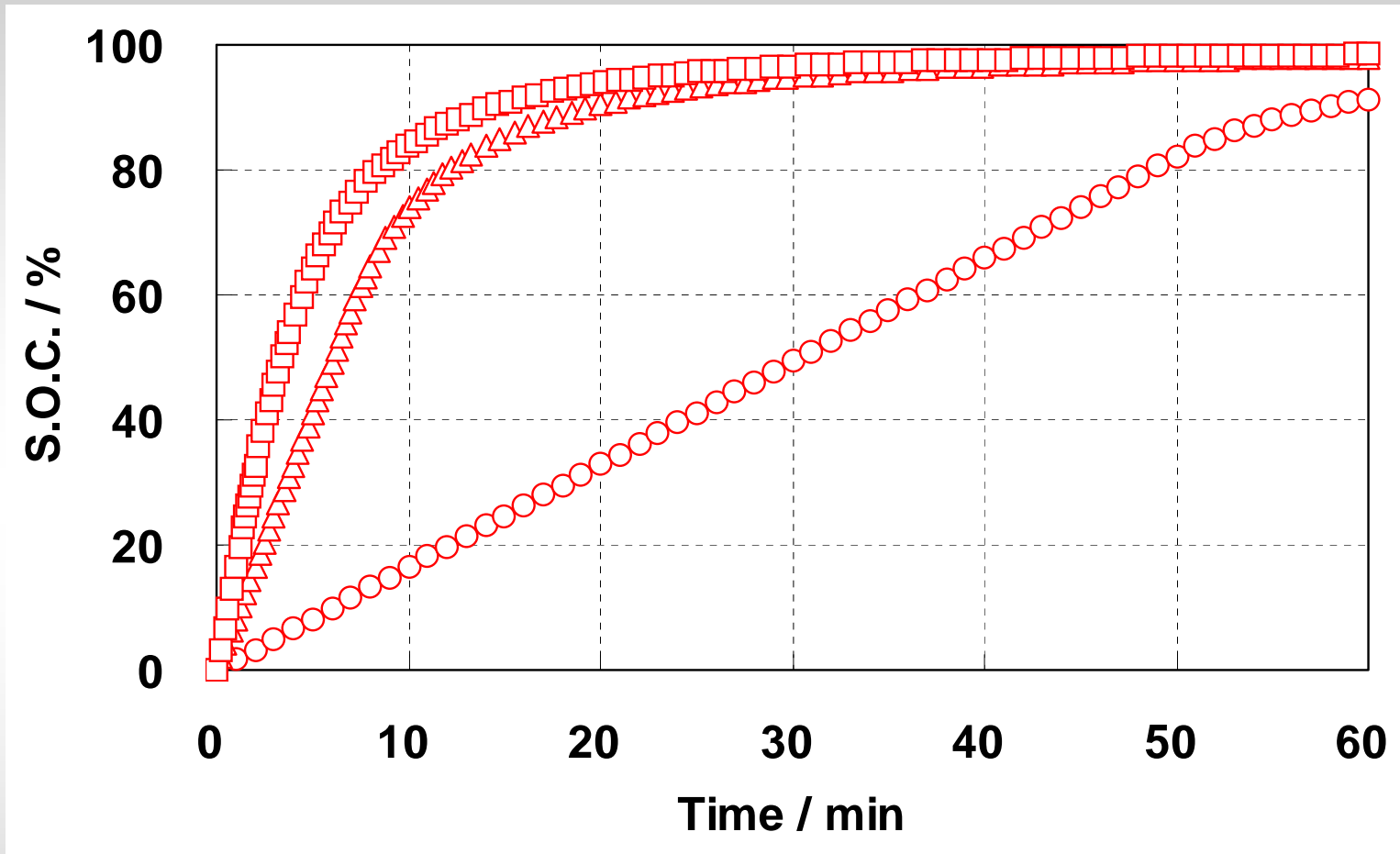
Positive electrode

Negative electrode

Separator

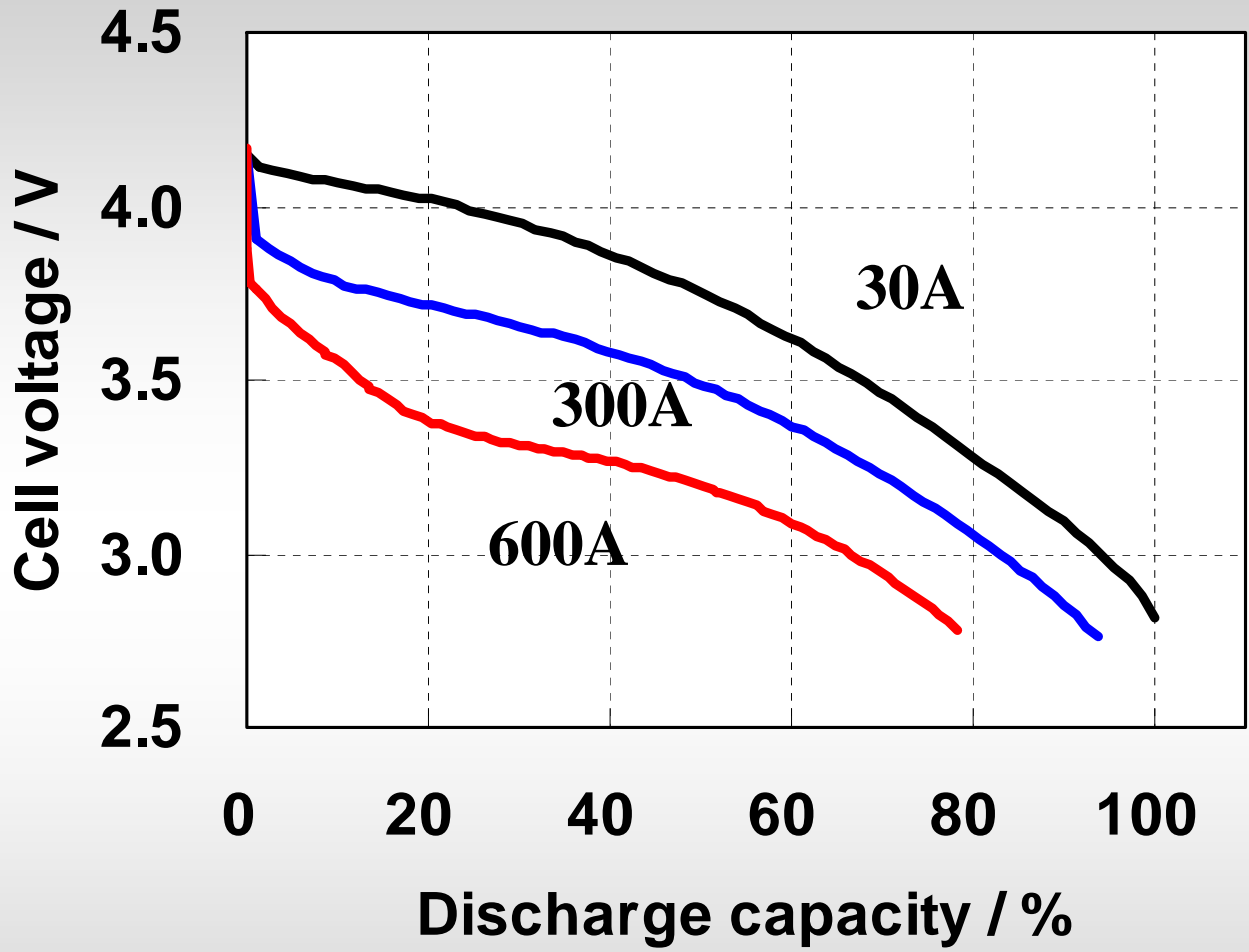


Quick Charge Performance of LIM30H



Charge : (○)30 , (△)150, and (□)300 A to 4.15 V followed by constant voltage of its value for 3 hours at 25 °C

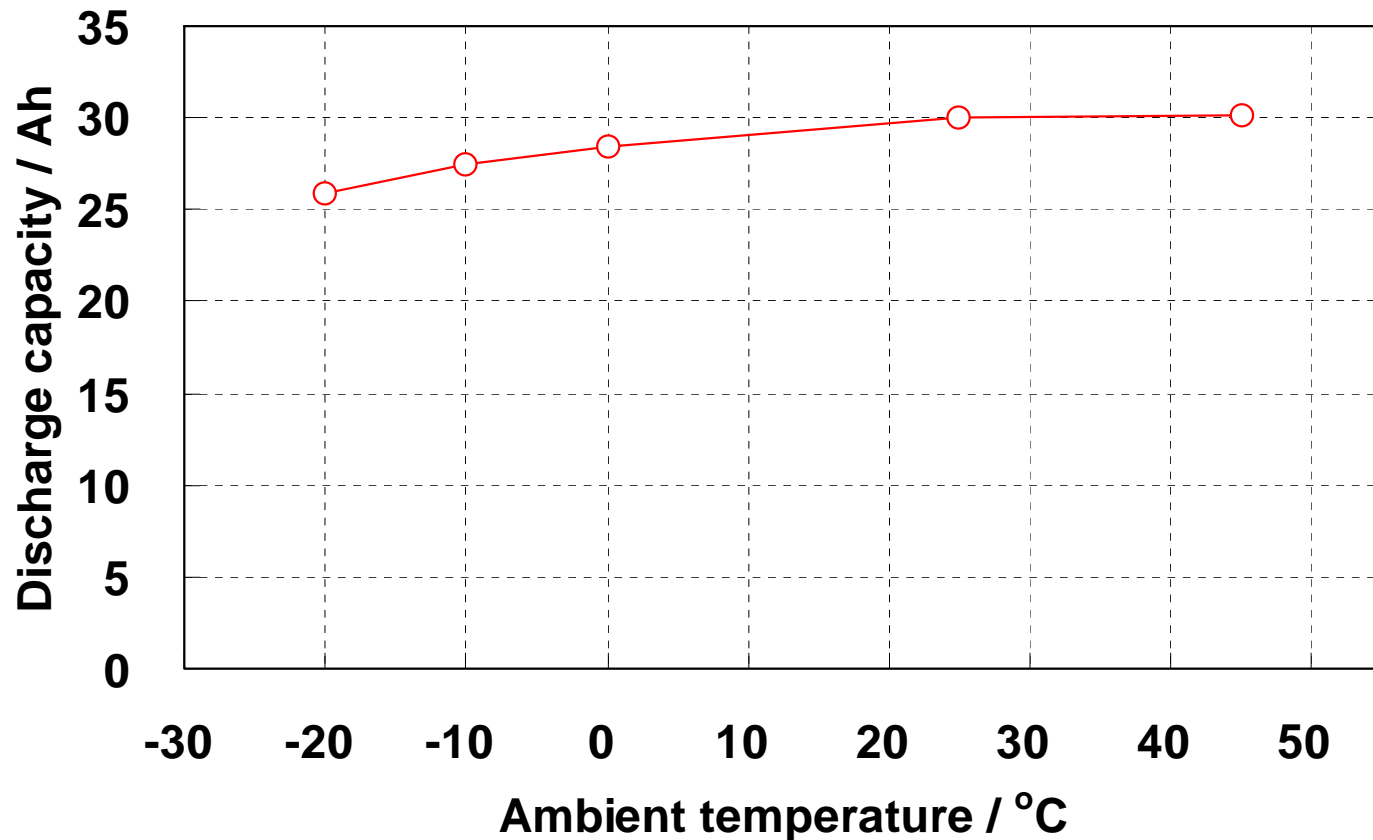
Discharge Performance of LIM30H



Charge : 30 A to 4.15 V followed by constant voltage of its value for 3 hours at 25°C

Discharge : Discharge with various current at 25°C

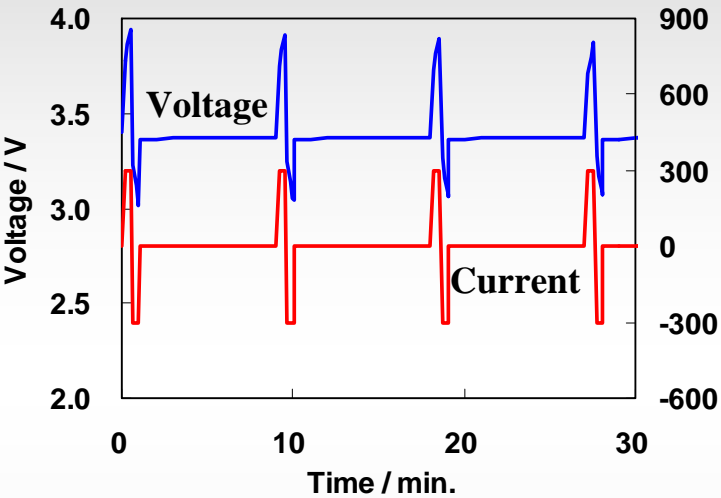
Discharge Capacities of LIM30H at Various Ambient Temperature



Charge : 30 A to 4.15 V followed by constant voltage for 3 hours at 25°C

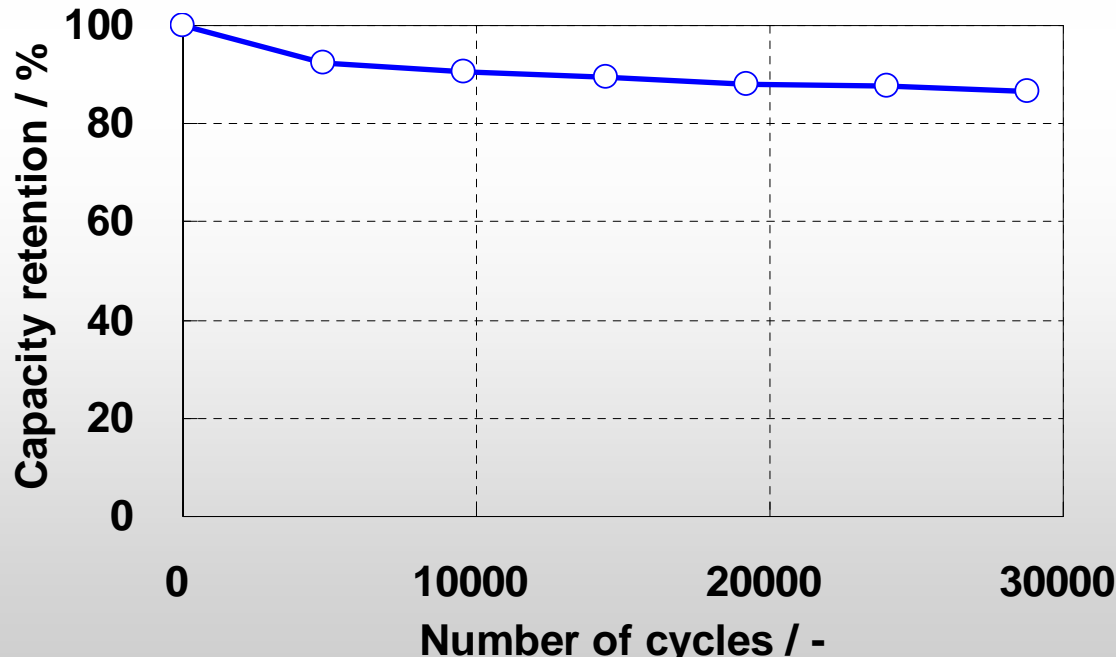
Discharge : 30 A to 2.75 V at various ambient temperature

Life Performance of LIM30H under Large Current Charge Discharge Pulse Cycle



300A pattern cycle:

Charge- 300A 30sec.
Discharge- 300A 30sec.
Rest- 480sec.



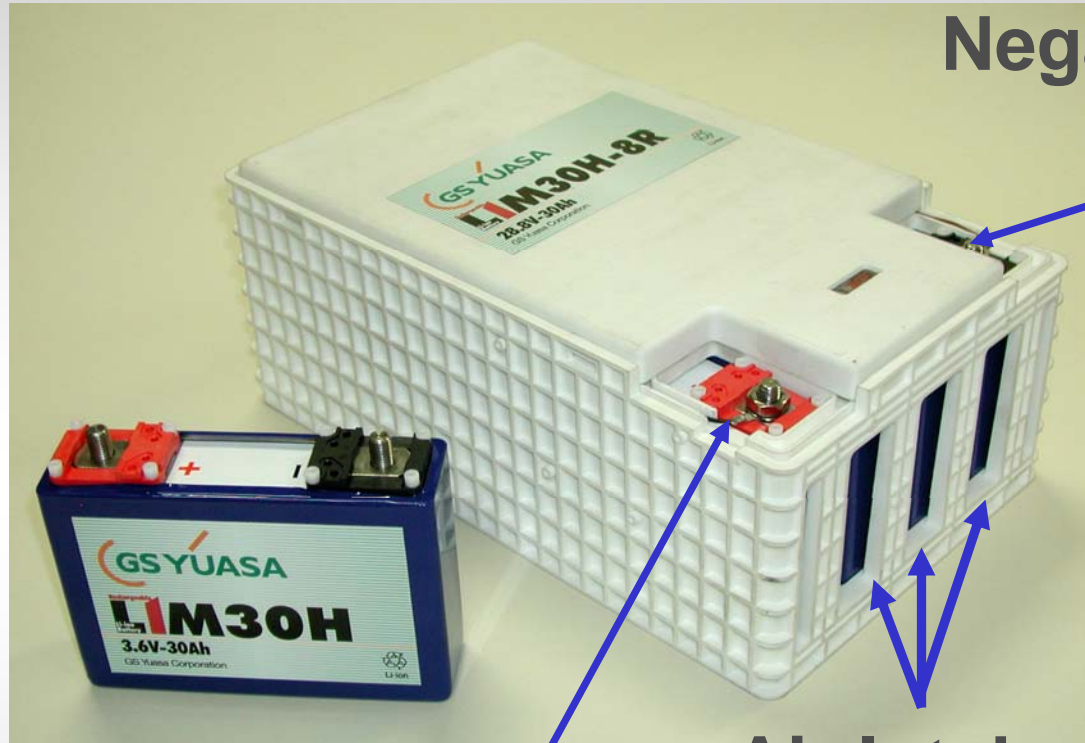
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LIM30H-8R Module Specifications

Items	Specifications
Cell	LIM30H (8 cells in series)
Nominal capacity	30 Ah
Nominal voltage	28.8 V (3.6 V / cell)
Operating voltage	20.0 – 33.6 V (2.5 – 4.2 V / cell)
Dimensions	W231 – D375 – H147 / mm
Mass	18.5 kg
Cooling	Designed for forced air cooling
Cell management	Cell Scanner(CS) installed

LIM30H-8R



Negative Terminal

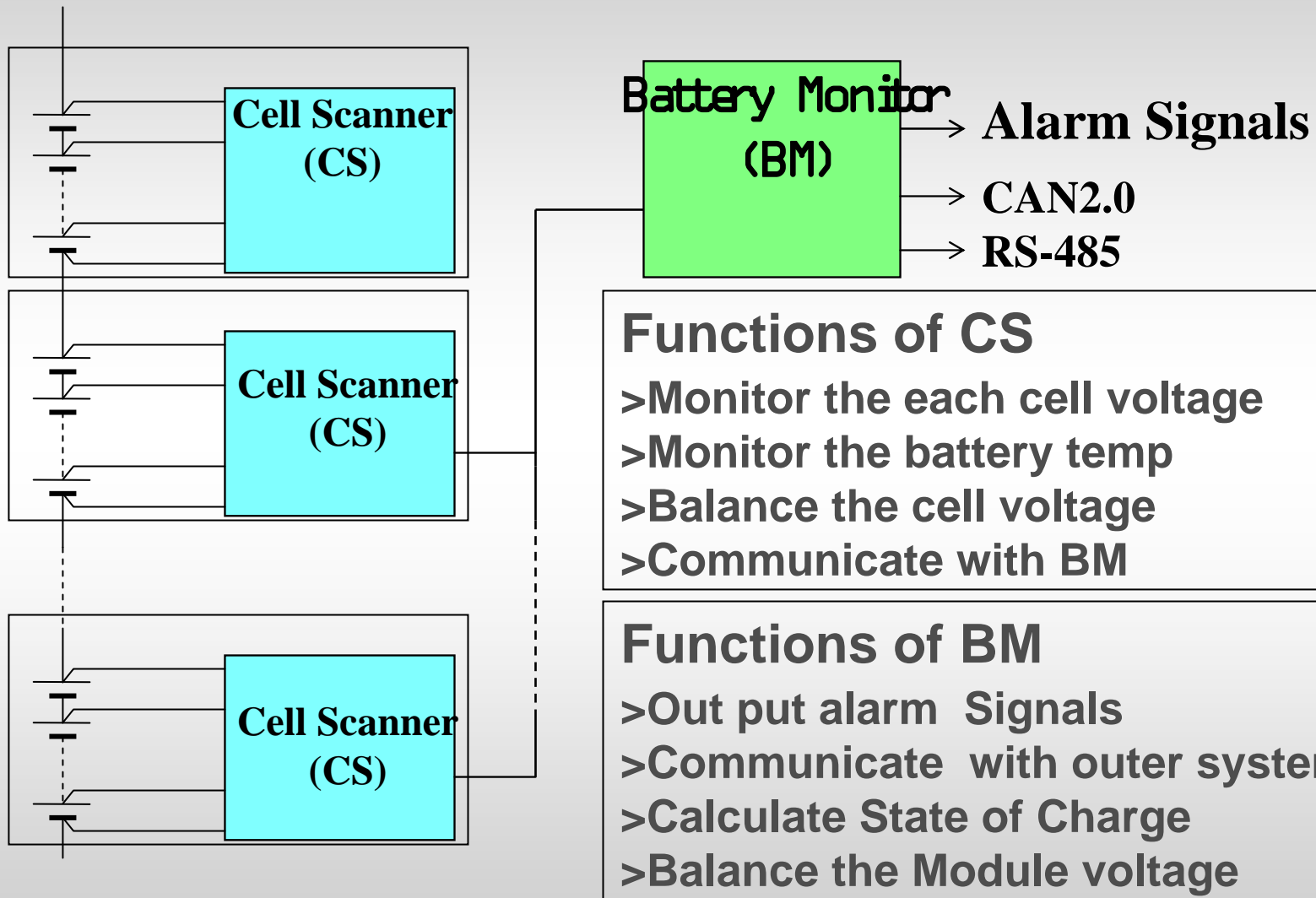
Cell Scanner

Air Intake

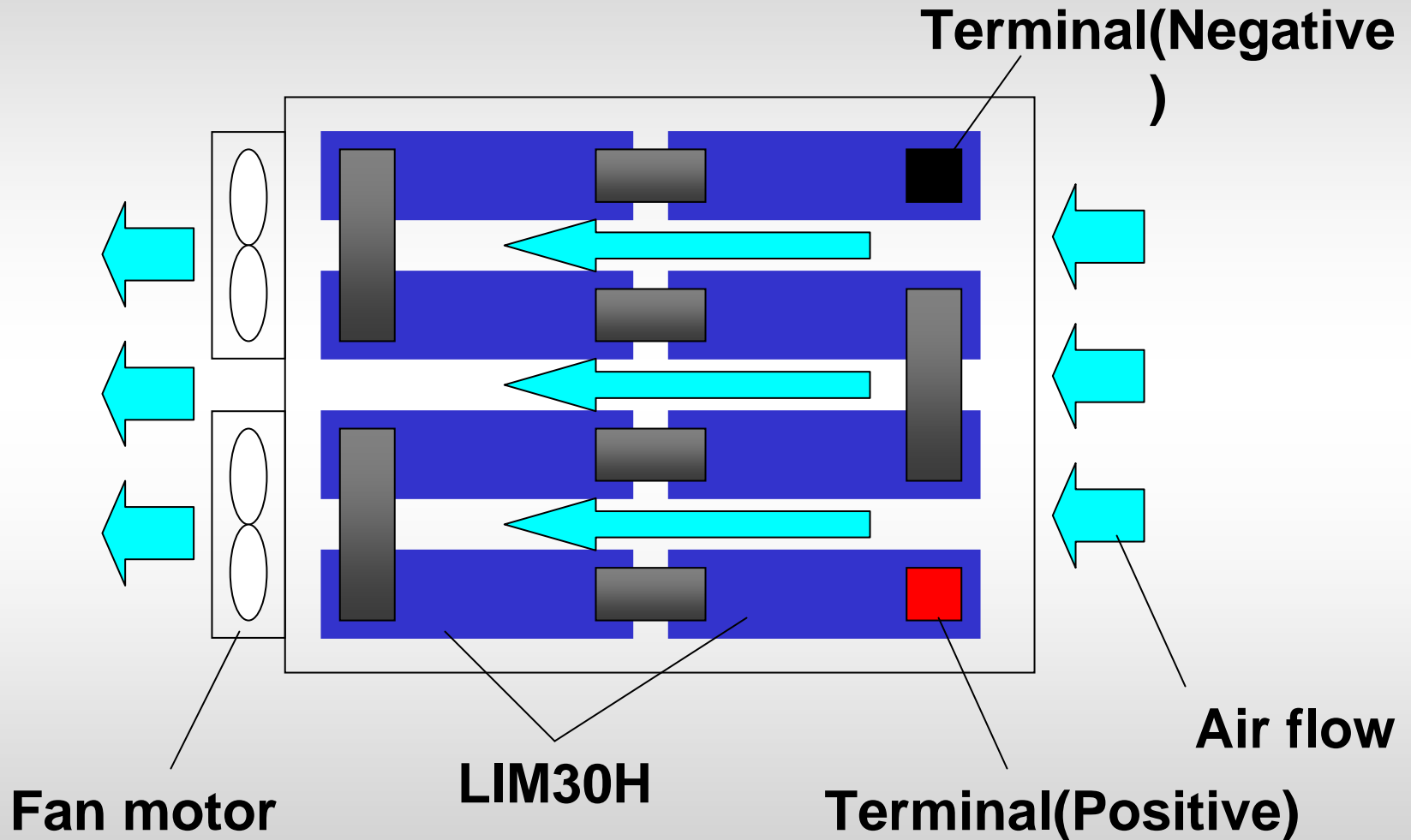
Positive Terminal



Battery Monitoring System of LIM30H-8R



Cooling Air Flow of LIM30H-8R



Battery powered tram

(Railway Technical Research Institute, Japan)-

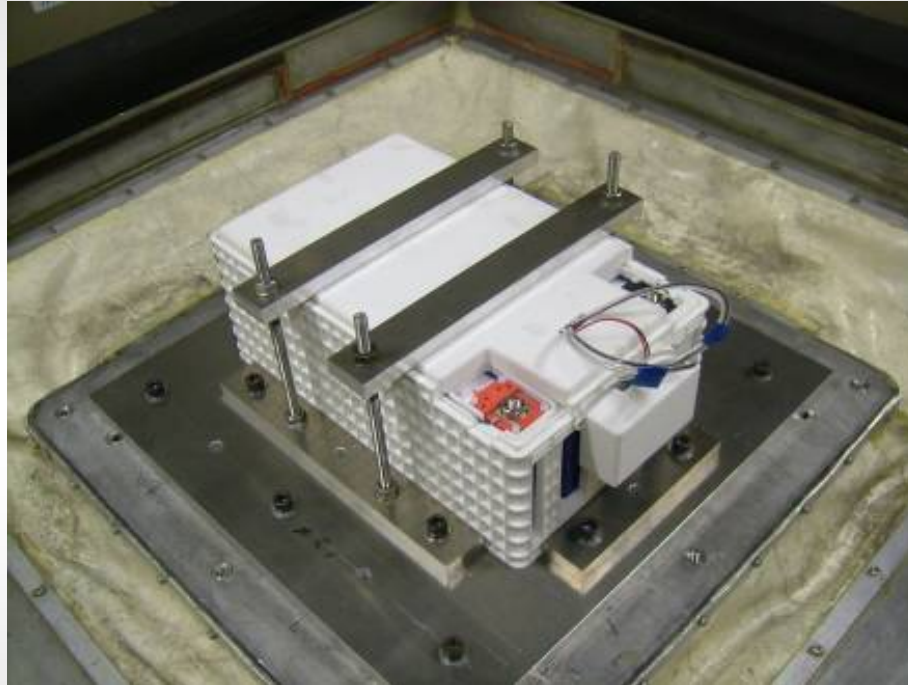


Cell **55Ah-class proto type**
(92W, 170L, 133H)

Battery system **168 cell-series**

LIM30-8

Environmental Test

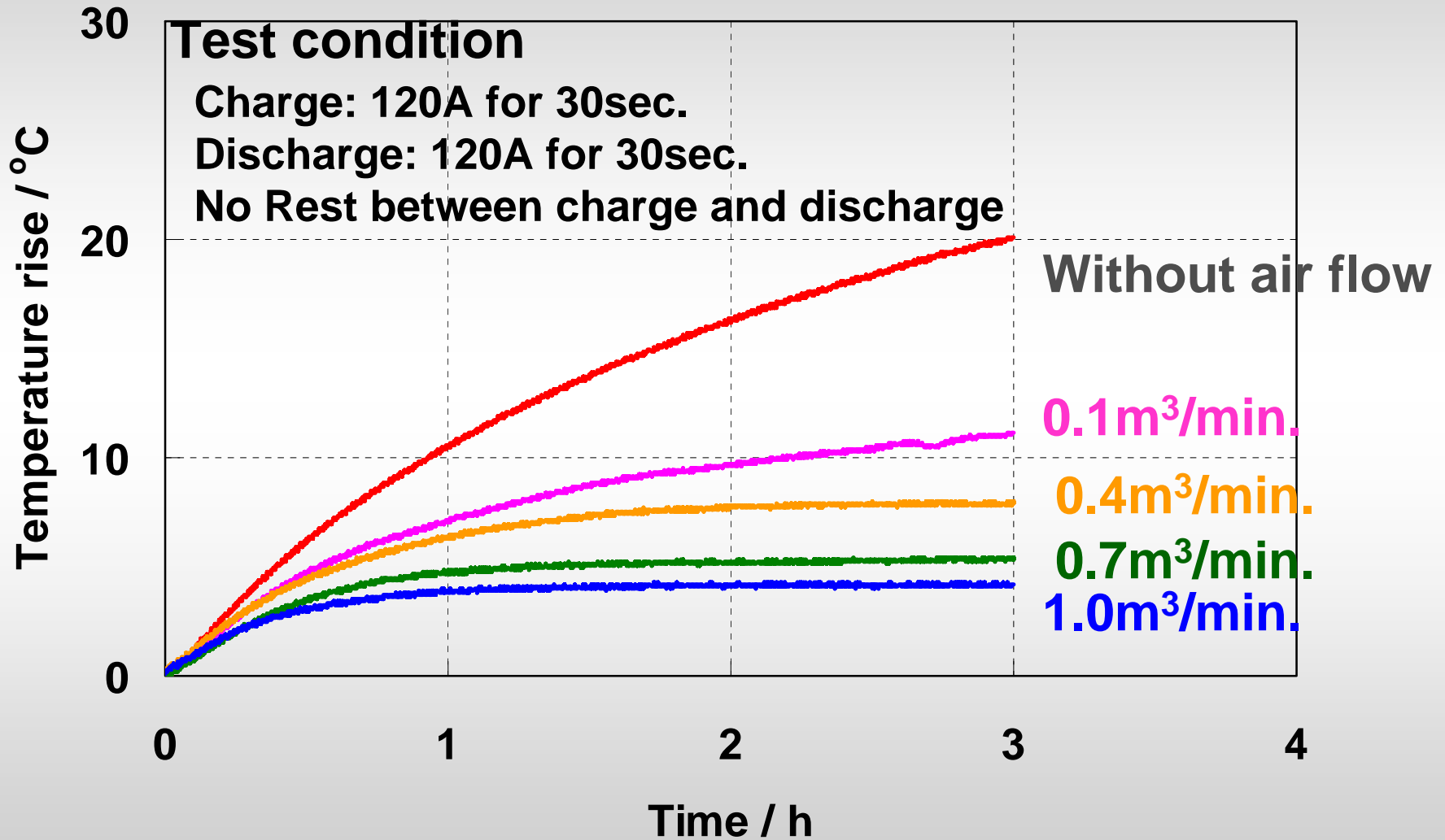


Vibration test

➤ UN3090

➤ JIS E 4031 2B (JIS : Japanese Industrial Standard)

Temperature Rise of LIM30H-8R with Large Current (120A) Operation with Various Air Flow

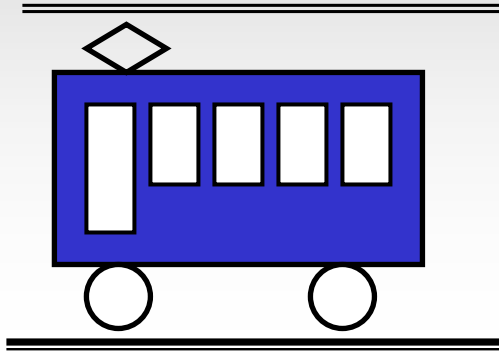


Agenda

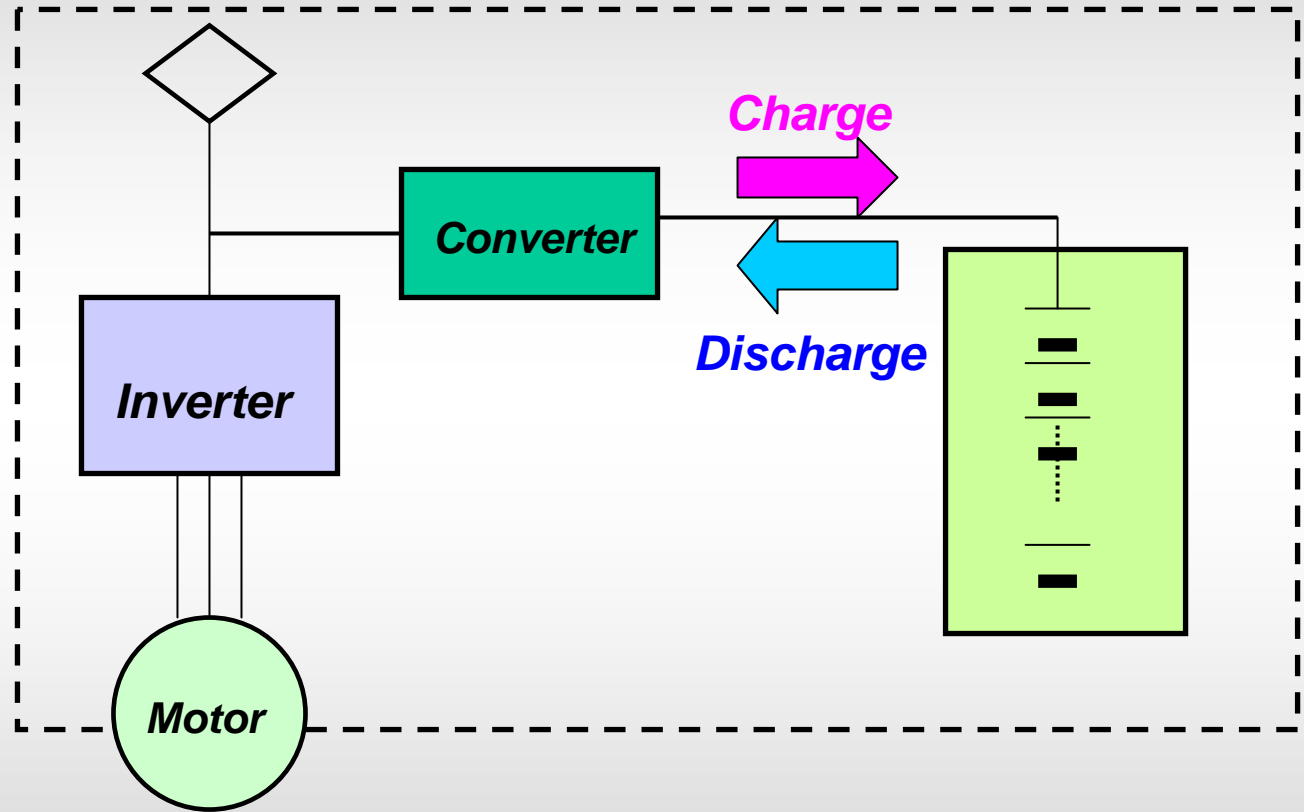
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Example of Hybrid Powered Energy System (Hybrid Railway Vehicle Power System)

Overhead wires

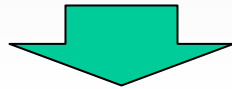


Fly-back line
(Rail)



Evaluation of Energy Efficiency for Hybrid Railway Vehicle Power System

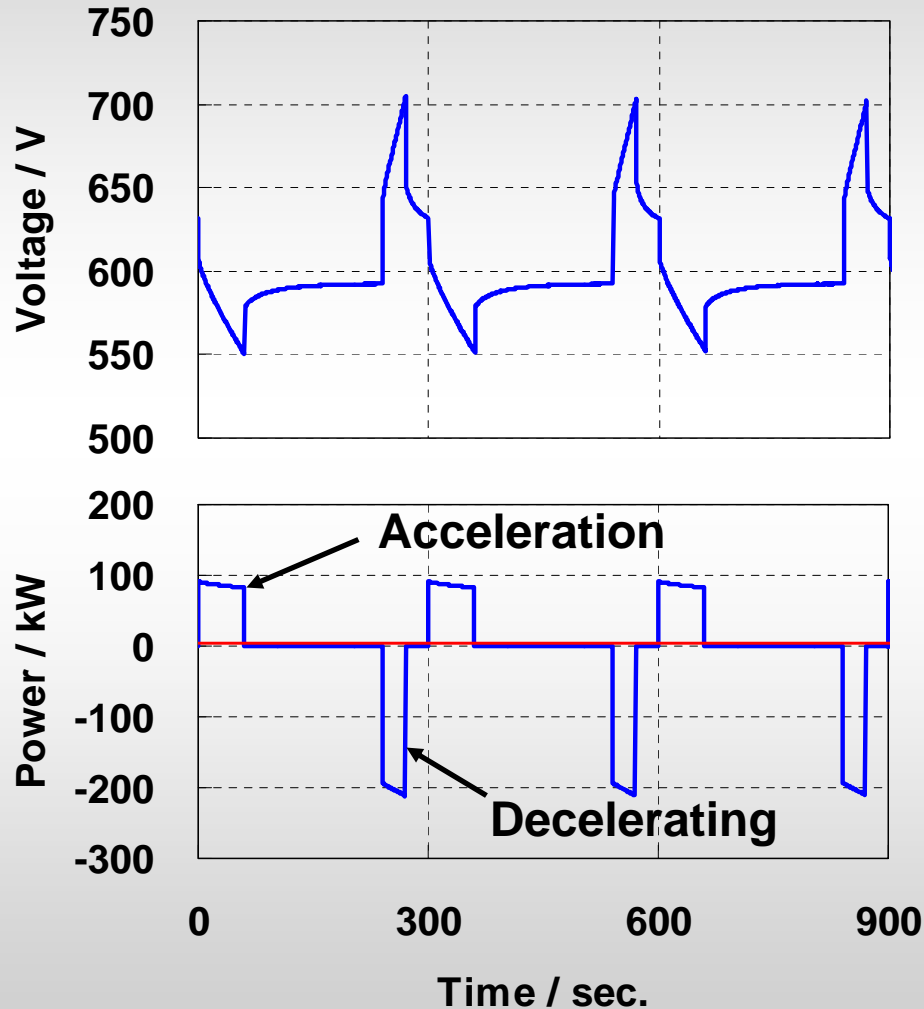
**Test Battery: LIM30H-8R-22series
(30Ah-634V)**



Charge discharge conditions:

- 1. Discharge (Acceleration assist): 90kW for 60 sec.**
- 2. Rest (Constant speed running): 180 sec.**
- 3. Charge (Regeneration at Decelerating): 200kW for 30 sec.**
- 4. Rest (Stop at the station): 30 sec.**

Result of Energy Efficiency Test for Hybrid Railway Vehicle Power System



Energy efficiency

$$\frac{\int W_{out} dt}{\int W_{in} dt}$$

$$= 82\%$$

Conclusions

Newly developed Large-sized Li-ion Battery Module(LIM30H-8R) for Hybrid Powered Energy System has the following features:

- **High rate charge and discharge capability**
- **Longer life performance under large current charge discharge pulse cycles**
- **CS (cell scanner) is included in each battery module, Battery Monitor communicates to vehicle**
- **Thermal management for large current continuous operation**
- **Higher energy efficiency suitable for hybrid energy system**

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