



SURFACE VEHICLE TECHNICAL INFORMATION REPORT

J3124™

JUN2018

Issued

2018-06

Industry Review of xEV Battery Size Standards

1. SCOPE

This Technical Information Report (TIR) will review the global industry battery size standards for xEV vehicles to provide guidance on available cell sizes for engineers developing battery powered vehicles. The TIR will include a review of the sizes and standards that are currently being developed or used for cylindrical cells, pouch (or polymer) cells, and for prismatic can cells. The lithium-ion cell will be the focus of this survey, but module and pack level size standards, where available, will also be included.

RATIONALE

This SAE Battery Size Standardization Technical Information Report is intended to provide comprehensive reference and background information pertaining to battery size standards for xEV vehicles in the global industry.

With the introduction of the lithium-ion battery cell in 1991 the portable power industry quickly consolidated to a common form factor based with an 18 mm diameter and a 65 mm height, today referred to as an 18650 cell. This remained the de-facto industry standard cell size for portable power applications until the advent of the “pouch” or “polymer” cell in the late 1990s. Due to the relative flexibility of the pouch manufacturing process many different sizes of cells were introduced ranging from small milli ampere-hour size cells up to cells with over 100 ampere-hours in capacity. In the late 1990s the prismatic hard packaged can cell was also introduced and is being used in many xEV products in many different sizes.

OEMs and system integrators have long espoused the value and need for developing a set of standard cell sizes in order to create multiple sources for cells and to help the battery industry drive down costs by increasing volumes. With different vehicle architectures, different applications, different markets and uses, and different philosophies vehicle manufacturers have wide variations in their requirements that drive different types of cells and mechanical design solutions. However, by using standard cells in their designs they are able to drive increased volumes across many cell suppliers which is one of the major drivers for cost reduction in lithium-ion cell manufacturing.

Today there are several organizations that have already begun developing battery size standards across the world, including the International Organization for Standardization (ISO), the Standardization Administration of China (SAC), the Verband der Automobilindustrie (VDA), and Deutsches Institut für Normung (DIN), and SAE International (SAE) are just a few of the organizations that are working on cell level standards. There are many similarities in these standards but they are also largely driven by the local automobile manufacturer's and regional government requirements.

As a next step after the completion of this report SAE would envision coordinating with these global standards groups to create specific set standards for the different on-road vehicles including Low Speed Electric Vehicles (LSEV), Automobiles, Buses, Heavy Duty and Commerical vehicles.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2018 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
http: //www.sae.org

SAE WEB ADDRESS:

Full document details: SAE J3124_201806

SAE values your input. To provide feedback on this Technical Report, please visit http://standards.sae.org/J3124_201806

INTRODUCTION

Standardizing around common cell, module or pack form factors offers multiple benefits, including: reducing development time, reducing system and RESS costs, improving serviceability, and package protecting future designs. Today, most commonality and standards have been created and driven by OEMs through regional governments and standards organizations.

Battery standardization has been evaluated in several areas. Beginning with the physical size and volume of the cell, module and pack; standardization of chemistries has been evaluated by several organizations; standardizing around performance characteristics, such as voltage and capacity; or some combination of these.

Past history of the lead acid battery industry is a good example of how standardization has been successful in the automotive sector, but this was done at the modular level, not the cell level. The highly energetic lithium ion battery technology, which requires a different electronic control architecture, and by nature of its chemistry, has pushed the technology to the cell level at this point in history. Therefore, this has created the opportunity to standardize at the cell level. Future module or pack level standards will eventually transpire as the industry matures.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1715 Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology

SAE J1715/2 Battery Terminology

SAE J1797 Recommended Practice for Packaging of Electric Vehicle Battery Modules

2.1.2 International Organization for Standardization (ISO)

ISO/IEC PAS 16898: 2012(E) – Electrically propelled road vehicles — Dimensions and designation of secondary lithium-ion cells

2.1.3 U.S. Department of Defense

MIL-PRF-32565 - BATTERY, RECHARGEABLE, SEALED, 6T LITHIUM-ION

2.1.4 Deutsches Institut für Normung (DIN)

E DIN 91252: 2014-04 – Electrically propelled vehicles — Battery systems — Design specification for lithium-ion battery cells

2.1.5 China Automotive Technology and Research Center (CATARC)

QC/T 840-2010 Specification and dimension of traction battery for electric vehicles

GB/T 34013-2017 Dimension of traction battery for electric vehicle

2.1.6 Verband Der Automobilindustri (VDA)

DIN SPEC 9152-2011-01 Electrically propelled vehicles – Battery systems – Design specification for lithium-ion battery cells

2.1.7 Industry References

Warner, J.T. (2015) "The Handbook of Lithium-Ion Battery Pack Design: Chemistry, Components, Types and Terminology", Elsevier, 1st Edition (Boston).

3. DEFINITIONS

SAE J1715 Hybrid Electric Vehicle (HEV) and Electric Vehicle (EV) Terminology

SAE J1715/2 Battery Terminology

3.1 Symbols

Li-ion = Lithium-Ion Batteries

PbA = Lead Acid Batteries

NiCd = Nickel Cadmium Batteries

NiMH = Nickel Metal Hydride Batteries

"+" = Positive Charged Electrode Polarity

"-" = Negative Charged Electrode Polarity

"L" = Length

"W" = Width

"H" = Height

4. THRESHOLD CRITERIA FOR STANDARDS

In reviewing existing industry standards, one area of discussion must include understanding what qualifies something as a standard. Many current standards are based on which cells were selected for various automotive programs, or which cells were available at the time. However, it may be worthwhile to evaluate a global size standard based on a set of quantitative criteria. One potential quantitative methodology may include evaluating individual cells, modules and packs based on sales volume, how many applications it is used in, and how many battery manufacturers make it. An example of these three criteria could come in the form of:

- Total annual sales volume - in annual units
- Number of users for a specific size cell, module, or pack - at least three OEMs
- Number of suppliers manufacturing that size - two or more manufacturers

5. CELL FORM FACTORS

Lithium-ion cells used in automotive xEV applications generally come in one of three different types: prismatic cans, laminate pouch, and cylindrical. In a review of current published or in process cell standards, more than 133 unique cell sizes can be found across all three form factors.

Prismatic can cells are either a deep-drawn metal can or an injection molded plastic can. An assembly of electrodes which may be wound or more commonly stacked are inserted into the can. The prismatic can is closed with a “lid” that is most often welded into place. The next cell form factor is the laminated pouch type cell. A pouch cell is characterized by being a very thin cell that uses a thin aluminum foil that is laminated with a polymer material to form the “pouch.” The cells are usually formed with depressions through either a drawing or vacuum process. The cell electrodes are stacked and assembled into those depressions and the sides are sealed with a thermal welding process to seal the cells. Finally, the cylindrical cell is a deep drawn metal can in which a wound electrode assembly is installed. The lid of the cell is either crimped or more commonly welded into place (Warner, 2015).

6. TERMINALS

Cells generally use one of three different electrical terminal types: weld pads, threaded male studs, or threaded female terminals. Welded terminal pads are most often either of copper or aluminum and are frequently nickel plated but may also be made of brass or stainless steel. At the module level power and current terminals most frequently use a mechanical male or female threaded terminal in order to facilitate assembly and repair. Packs tend to use one of a variety of commonly available connectors designed for xEV vehicle use (Warner, 2015).

7. NORTH AMERICAN STANDARDS

7.1 SAE International (SAE)

SAE International is a global standards setting organization focusing on automotive, aerospace and commercial vehicle standards by more than 138,000 engineers and industry experts worldwide.

SAE J1797: 2016 - Recommended Practice for Packaging of Electric Vehicle Battery Modules

SAE's J1797 standard was originally published in 1997 and reconfirmed in 2016. It defines a set of four standard sizes for modules, as well as defining a set of chemistries, voltages, mechanical interfaces, module retention, system interfaces, high power connection requirements, venting and emissions interfaces, and terminal types and locations. The standard goes on to include monitoring and control interfaces for voltage, temperature, and thermal management. Finally, it includes description of labeling and marking requirements as well as packaging and stackability and shipping and handling requirements.

7.2 U.S. Department of Defense

The United States Department of Defense issued military specification MIL-PRF-32565 on 17 November 2016 “BATTERY, RECHARGEABLE, SEALED, 6T LITHIUM-ION.” This specification outlines the general requirements for secondary, 24 volt lithium-ion batteries in the 6T form factor 253 mm width x 266 mm depth x 205 mm height. The 6T form factor carries over from previous generation lead acid batteries used in many military applications. The 6T battery is defined as a “pack” as it includes interconnected battery modules that have been configured for a specific energy storage application or “system” – a completely functional energy storage system consisting of the pack(s) and necessary ancillary subsystems for physical support, thermal management, and electronic control.

MIL-PRF-32565 groups these batteries into three types according to their minimum capacity and maximum Hazard Severity Level as defined by SAE J2464 for the overcharge abuse and battery nail penetration safety tests:

- Type 1 has a minimum capacity of 55 Ah and maximum Hazard Severity Level of 4 for overcharge and battery nail penetration;
- Type 2 has a minimum capacity of 55 Ah and maximum Hazard Severity Level of 6 for overcharge and battery nail penetration;

- Type 3 has a minimum capacity of 90 Ah and a maximum Hazard Severity Level of 6 for overcharge and battery nail penetration.

7.2.1 Terminals

6T batteries have terminal posts with threaded sockets. The threaded socket of the negative terminal post has a depth of 13 mm minimum, with a 5/16-18 thread and the threaded socket of the positive terminal post must have a depth of 13 mm minimum, with a 3/8-16 thread.

8. EUROPEAN STANDARDS

8.1 International Organization for Standardization (ISO)

ISO is an independent, non-governmental international organization with a membership of 161 national standards bodies. Through its members, it brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges.

Publicly Available Specification (PAS) 16898: 2012 – Electrically propelled road vehicles -- Dimensions and designation of secondary lithium-ion cells

ISO/IEC PAS 16898: 2012 was reconfirmed in 2016 and specifies a designation system as well as the shapes and dimensions for secondary lithium-ion cells for integration into battery packs and systems used in electrically propelled road vehicles including the position of the terminals and any over-pressure safety device (OPSD). It is related to cylindrical, prismatic and pouch cells.

The cell designation according to ISO/IEC PAS 16898: 2012 is intended to be applied to the cells used for electrically propelled road vehicles. ISO/IEC PAS 16898: 2012 does not apply to cells specifically used for mopeds, motorcycles and vehicles not primarily defined as road vehicles, i.e., material handling trucks or forklifts.

The cell dimensions listed in ISO/IEC PAS 16898: 2012 are recommended but not restricted for use in passenger cars up to 3.5 tons.

The inner design, the cell chemistry, the electrical characteristics and any further properties of the cells are not defined in ISO/IEC PAS 16898: 2012.

8.2 German Institute for Standardization (DIN)

DIN is acknowledged as the sole national standards body in Germany. More than 30,000 experts from industry, research, consumer protection and the public sector work together at DIN to develop market-oriented standards and specifications that promote global trade and innovations, assure efficiency and quality, and help protect the environment and society as a whole.

8.2.1 DIN 91252 - Electrically propelled road vehicles - Battery systems - Design specifications for Lithium-Ion battery cells

- 8.3 Verband Der Automobilindustri (VDA) - The German Association of the Automotive Industry (VDA) consists of more than 620 companies involved in production for the automotive industry in the Federal Republic of Germany. The members are divided into three manufacturer groups: automobile manufacturers, automotive suppliers, and trailers, special bodies, buses. These three manufacturer groups find their representation in three divisions with each assigned a managing director. More than 70 employees in 20 departments actively pursue the interests of the German automotive industry.

9. ASIAN STANDARDS

- 9.1 Standardization Administration of China (SAC) – The Standardization Administration of China (SAC) is under the control of General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and is authorized by the State Council to carry out centralized administration for standardization in China.
- 9.2 China Automotive Technology and Research Center (CATARC) - CATARC is a science research institute established in 1985 to meet China's need of managing the automotive industry. CATARC is the national centralized technical administration of auto standardization and regulations.
- 9.2.1 QC/T 840-2010 Specification and dimension of traction battery for electric vehicles was released in November 2010. The standard lists eight dimensions, including prismatic, pouch and cylindrical. The standard is classified according to nominal voltage and rated capacity, and the optimum value of length (diameter), width and height is proposed. *However, this standard may no longer be applicable to the current state of technology in the industry.*
- 9.2.2 In 2016, SAC issued a plan for the release of a GB/T standard to replace QC/T 840/2010, naming it GB/T 34013-2017 "Dimension of the traction battery for electric vehicles." CATARC is responsible for organizing the industry including OEMs, and battery manufacturers, who come together to work on this GB/T standard. Due to the complexity of the subject, it is expected to take several years to finish the new GB/T standard and replace QC/T 840-2010. However, some preliminary specifications are included in this report.

10. CURRENT STANDARD CELL SIZES

10.1 Prismatic Can

The prismatic can represents one of the most frequently used lithium-ion battery cells for transportation applications. These are usually composed of a deep drawn metal can with a welded lid that contains the active material components of the cell. The lid usually has the terminals isolated from the metal for the electrical connections which can be a welding pad, bolt or nut for fastening electrical connections. Terminals are most frequently located on the same side, but may also be located on opposite ends of the can, or in some cases the can itself may be considered "case positive" and used as the terminal.

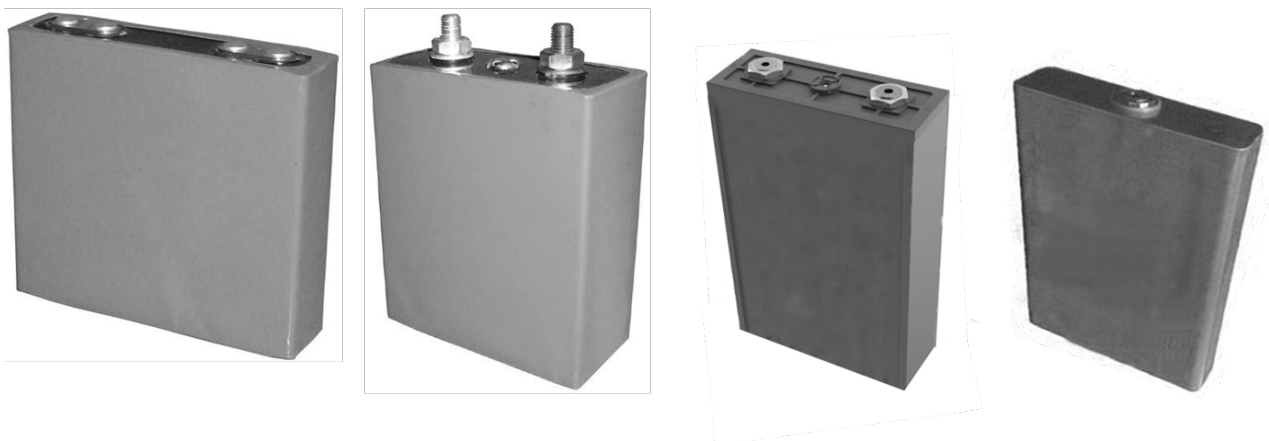


Figure 1 – (A) Same side terminals – weld pads, (B) Same side terminals – male thread, (D) Same side terminals – female thread, (E) Opposite side terminals – female thread