METRIC
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PERFORMANCE SPECIFICATION

BATTERY, RECHARGEABLE, SEALED, 6T LITHIUM-ION

Comments, suggestions, or questions on this document should be addressed to U.S. Army Tank-Automotive Research, Development and Engineering Center, ATTN: RDTA-SIE-ES-SI MS #268, 6501 E. 11 Mile Road, Warren, MI 48397-5000 or sent by email to usarmy.detroit.rdecom.mbx.tardec-standardization@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

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DISTRIBUTION STATEMENT A. Approved for public release.

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TABLE

This specification is approved for use by the U.S. Army Tank-automotive and Armaments Command and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This performance specification contains general requirements for secondary (rechargeable) nominal 24 volt lithium-ion (Li-ion) batteries having the 6T form factor in accordance with STANAG 4015. The batteries described in this specification are intended to be used as power sources for automotive starting, lighting, & ignition (SLI), and auxiliary electronics (such as deep cycle and silent watch operations with the vehicle engine off). This specification groups 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 specified in this document: 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; and Type 3 has a minimum capacity of 90 Ah and a maximum Hazard Severity Level of 6 for overcharge and battery nail penetration.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL STANDARDS

FED-STD-595/20150 - Brown, Semigloss

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-38999 - Connectors, Electrical Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded or Breech Coupling), Environment Resistant with Crimp Removable

Contacts or Hermetically Sealed with Fixed, Solderable Contacts, General Specification for

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-130	-	Identification Marking of U.S. Military Property
MIL-STD-171	-	Finishing of Metal and Wood Surfaces
MIL-STD-202-301	-	Method 301, Dielectric Withstanding Voltage
MIL-STD-202-302	-	Method 302, Insulation Resistance
MIL-STD-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-464	-	Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-889	-	Dissimilar Metals.
MIL-STD-1275	-	Characteristics of 28 Volt DC Input Power to Utilization Equipment in Military Vehicles
MIL-STD-1472	-	Design Criteria Standard for Human Engineering.

(Copies of these documents are available online at http://quicksearch.dla.mil.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ARMY-TACOM PURCHASE DESCRIPTIONS (ATPD)

ATPD 2404	-	Environmental Conditions for the Armored Brigade Combat Team Tracked Vehicle Systems

(Copies of this document are available from U.S. Army RDECOM, Tank Automotive Research, Development and Engineering Center, ATTN: RDTA-SIE-ES-SI MS #268, 6501 E. 11 Mile Road, Warren, MI 48397-5000 or can be requested by sending an email to mailto:usarmy.detroit.rdecom.mbx.tardec-standardization@mail.mil.)

CODE OF FEDERAL REGULATIONS

29 CFR 1910.1200	-	Hazardous Substances

(Copies of this document are available online at www.gpoaccess.gov/cfr/index.html.)

DEFENSE FEDERAL ACQUISITION SUPPLIMENT

DFARS 252.211-7003	-	Item Identification and Valuation

(Copies of this document are available online at http://www.acq.osd.mil)

DEPARTMENT OF THE ARMY

FM 3-11.5	-	Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Decontamination

(Copies of these documents are available online at http://www.army.mil/usapa/index.html.)

ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA/625R-96/010b	-	Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition.

(Copies of this document are available online at http://www.epa.gov/ttn/amtic/airtox.html.)

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

NAVSEA INSTRUCTION 9310.1	-	Naval Lithium Battery Safety Program
S9310-AQ-SAF-010	-	Technical Manual for Batteries, Navy Lithium Safety Program Responsibilities and Procedures

(Copies of these documents may be obtained from the Naval Surface Warfare Center, Indiana 300 Highway 361, Building 64, Crane IN 47522-5001.)

TACOM DRAWINGS

12350824	-	Paint System Chemical Agent Resistive Coating

(Copies of this document are available from U.S. Army RDECOM, Tank Automotive Research, Development and Engineering Center, ATTN: RDTA-SIE-ES-SI MS #268, 6501 E. 11 Mile

Road, Warren, MI 48397-5000 or can be requested by sending an email to mailto:usarmy.detroit.rdecom.mbx.tardec-standardization@mail.mil.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

NCSL Z540.3	-	Requirements for Calibration of Measuring and Test Equipment.

(Copies of this document are available online at http://www.ansi.org/.)

AMERICAN SOCIETY OF MECANICAL ENGINEERS (ASME)

ASME Y14.38	-	Abbreviations and Acronyms for Use on Drawings and Related Documents.

(Copies of this document are available online at http://www.asme.org.)

ASSOCIATION OF CONNECTING ELECTRONICS INDUSTRIES (IPC)

IPC J-STD-001	-	Requirements for Soldered Electrical and Electronic Assemblies
IPC-A-610	-	Acceptability of Electronic Assemblies

(Copies of these documents are available online at www.ipc.org.)

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-4-2	-	Electromagnetic Compatibility (EMC) – Part 4-2: Testing and measurements techniques – Electrostatic Discharge Immunity Test

(Copies of this document are available online at http://www.iec.ch.)

INTERNATIONAL ORGANIZATION FOR STANDARDS (ISO)

ISO 10012	-	Measurement management systems - Requirements for measurement processes and measuring equipment.

ISO 11898-1	-	Road Vehicles – Controller Area Network (CAN) – Part 1: Data Link Layer and Physical Signaling
ISO 11898-2	-	Road Vehicles – Controller Area Network (CAN) – Part 2: High-Speed Medium Access Unit
ISO 11898-3	-	Road Vehicles – Controller Area Network (CAN) – Part 3: Low-Speed, Fault-Tolerant, Medium-Dependent Interface
ISO 11898-4	-	Road Vehicles - Controller Area Network (CAN) Part 4: Time-Triggered Communication
ISO 11898-5	-	Road Vehicles – Controller Area Networks (CAN) Part 5: High-Speed Medium Access Unit with Low-Power Mode

(Copies of this document are available online at http://www.iso.org/iso/home.htm.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE AS478	-	Identification Marking Methods (DoD Adopted)
SAE J1939	-	Serial Control and Communications Heavy Duty Vehicle Network – Top Level Document
SAE J1939-81	-	Network Management
SAE J2464	-	Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing.

(Copies of these documents are available online at http://www.sae.org/.)

TECHAMERICA

GEIA-STD-0005-1	-	Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-Free Solder
GEIA-STD-0005-2	-	Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems

GEIA-STD-0006	-	Requirements for Using Solder Dip to Replace the Finish on Electronic Piece Parts

(Copies of these documents are available online at www.geia.org.)

UNDERWRITER LABORATORIES (UL)

UL 94	-	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

(Copies of this document are available online at http://www.ul.com.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Qualification. Batteries furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.1.1 and 6.4).

3.2 Materials. Conformance shall be verified and demonstrated by inspection of contractor records providing objective quality evidence or certification that design, construction, processing, and materials conform to requirements. Applicable records shall include drawings, specifications, design data, receiving inspection records, processing and quality control standards, vendor catalogs and certifications, industry standards, test reports, and rating data.

3.2.1 Recycled, recovered, environmentally preferable, or bio based materials. Recycled, recovered, environmentally preferable, or biobased materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.2.2 Metals. All cell or battery metals which do not enter into the basic electrochemical reaction of the cell, shall resist, or be treated to resist, corrosion. Vendor certification shall be required.

3.2.3 Dissimilar metals. When dissimilar metals, which would adversely affect battery performance, are used in intimate contact with each other, protection against electrolysis and corrosion shall be provided (see MIL-STD-889). Vendor certification shall be required.

3.2.4 Compounds.

3.2.4.1 Insulating compounds.

3.2.4.1.1 Potting/sealing compounds, flow and shrinkage. Insulating, impregnating, potting and sealing compounds used in manufacturing shall be capable of performing their intended purpose under the use conditions described by this specification. Compounds shall not inhibit the operation of any safety features (such as air pressure equalization port, overpressure relief device or heater). When tested in accordance with 4.4.3, the insulating, impregnating, potting and sealing compounds shall not flow at high temperature, and shall not crack or draw away from the sides of a container at low temperature. Any compound used shall be non-flammable and non-toxic (see 3.17). Vendor certification shall be required.

3.2.4.1.2 Insulating compounds for electrical connectors, wires, and tabs. All points inside a battery that have positive and negative polarity in close proximity shall have not less than one layer of insulation between the positive and negative. Insulating material, or layers of multiple insulating materials between positive and negative points, shall have the following characteristics at a minimum:

a. Softening temperature: Not less than 150 °C (see 6.3.38)

b. Lengthwise shrinkage: Not greater than 3 percent after application

c. Thickness: Not less than 0.127 mm.

Material shall not shrink, soften, or crack during any of the tests of this specification with the exception of battery abuse tests (see 4.10.2.7), unless specified otherwise. The material shall be non-flammable, non-toxic, and impervious to the electrolyte of the battery (see 3.17). Vendor certification shall be required.

3.2.4.2 Elastomeric materials. All elastomeric materials used in the battery shall show no cracks, blisters or other deterioration, nor cause degradation of battery performance after being tested as specified herein, with the exception of destructive testing. Any elastomeric material used shall be non-flammable and non-toxic (see 3.17). Vendor certification shall be required.

3.3 Manufacturing.

3.3.1 Physical characteristics. Each cell and battery shall be free of visual and mechanical defects in accordance with 3.19 before and after being subjected to the testing in section 4.

3.3.2 Dimensions and weights. When examined in accordance with 4.4.2.3, the dimensions and weights of each battery shall be as defined in figure 1 through figure 4 and in table I.

TABLE I. Physical and electrical requirements.

Characteristics	Type 1 minimum values (at normal conditions unless specified)	Type 2 minimum values (at normal conditions unless specified)	Type 3 minimum values (at normal conditions unless specified)
Type Classification:	6TLi-Type1	6TLi-Type2	6TLi-Type3
Class:	Li-ion	Li-ion	Li-ion
Color:	"Coyote Brown"	"Coyote Brown"	"Coyote Brown"
Weight (max):	30 kg	30 kg	30 kg
Nominal voltage:	24 V	24 V	24 V
Full charge capacity (min at 1 hr. rate):	55 Ah (at 22 °C)	55 Ah (at 22 °C)	90 Ah (at 22 °C)
Cranking amps (no pre-heating):	1100 A for 30 sec at 55 °C 600 A for 30 sec at -18 °C 300 A for 30 sec at -32 °C 200 A for 30 sec at -40 °C	1100 A for 30 sec at 55 °C 600 A for 30 sec at -18 °C 300 A for 30 sec at -32 °C 200 A for 30 sec at -40 °C	1100 A for 30 sec at 55 °C 1100 A for 30 sec at -18 °C 600 A for 30 sec at -32 °C 400 A for 30 sec at -40 °C
Cranking amps (10 minute pre-heating):	1100 A for 30 sec at -18 °C	1100 A for 30 sec at -18 °C	1100 A for 30 sec at -18 °C
Cranking amps (30 minute pre-heating)	600 A for 30 sec at -48 °C	600 A for 30 sec at -48 °C	1100 A for 30 sec at -48 °C
Deep cycle life:	1000 cycles at 38 °C 500 cycles at 50 °C	1000 cycles at 38 °C 500 cycles at 50 °C	1000 cycles at 38 °C 500 cycles at 50 °C
Battery service life	5 years	5 years	5 years
Continuous current discharge rating (55 °C):	120 A	120 A	180 A
Continuous current charge rating (55 °C):	60 A	60 A	90 A
Pulse load rating (55 °C):	1100 A (at 30 seconds)	1100 A (at 30 seconds)	1100 A (at 30 seconds)
Operating temperature range:	-46 to 71 °C	-46 to 71 °C	-46 to 71 °C
Storage temperature range:	-54 to 88 °C	-54 to 88 °C	-54 to 88 °C
Minimum cranking voltage (below 0 °C)	14.4 V	14.4 V	14.4 V
Number of batteries capable of being connected in series	1	1	1
Number of batteries capable of being connected in parallel	12	12	12
SAE J2464 Hazard Severity Level (battery nail penetration and overcharge abuse only)	≤ 4	≤ 6	≤ 6
SAE J2464 Hazard Severity Level (battery projectile penetration only)	≤ 6	≤ 6	≤ 6

3.3.3 Electrical interfaces.

3.3.3.1 Terminal posts and threaded sockets. Batteries shall have terminal posts with threaded sockets which are able to maintain a seal under environmental and test conditions specified herein (see 3.8.6 and 4.7.5). The threaded socket of the negative terminal post shall have a depth of 13 mm minimum, with a 5/16-18 thread. The threaded socket of the positive terminal post shall have a depth of 13 mm minimum, with a 3/8-16 thread. The positive terminal post shall be identified by a "+," a "POS," or a "P," and the negative terminal post by a "-," a "NEG," or an "N" as shown in figure 5. The terminal posts design shall be in accordance with figure 5. Location of the threaded sockets on the battery shall be in accordance with figure 1. The area around each threaded socket shall be an electrically conductive pad with a diameter of 27±1 mm (see figure 1). The electrically conductive pad shall be at least 2 mm above the top surface of the battery or any coatings applied to the battery, and may extend above the surface of the battery by no more than 3 mm. The area around the electrically conductive pad shall be made of an electrically insulating material to prevent shorting to the battery case from the cables. This electrically insulating area shall have a diameter of 54±1 mm from the center of the threaded sockets, and the height shall be no more than 1 mm from the top surface of the battery. Assembly of the terminal posts into the threaded sockets shall require only finger tight plus one quarter to one half turn. An applied torque of up to 28.25 Newton-meter (Nm), in the clockwise direction, shall not cause damage to the threaded sockets, terminal posts, terminal housing, or any other part of the battery. Terminal material shall be compatible with use of standard vehicle lead acid battery clamps and cables. Battery clamps shall support 15 kg of weight each without slipping off of the terminal post adapter. See 4.4.2.4.1 for verification method.

3.3.3.2 Communication interface. A communication interface for the battery shall be provided for controller area networks (CAN) communication, configuration, and other necessary signals for the battery management system. The connector for the unit shall be located on the top of the battery case (see figure 1) and in such a fashion as to avoid moisture or contamination of the connector. The connector shall be MIL-DTL-38999 Series III, with insert arrangement C35, socket contacts, corrosion resistant stainless steel shell, and normal key position. The connector format and pin out shall be as shown in table II. The connector shall be inspected in accordance with 4.4.2.4.2.

TABLE II. J1 battery communications interface.

Signal name	J1 Contacts
Power (PWR)	1
Power (PWR) return	2
Dormant 1	3
Dormant 2	4
Master power switch in	5
Master power switch return	6
CAN A SHLD	7
CAN_A _H	8
CAN_A _L	9
CAN B SHLD	10
CAN B H	11
CAN_B _L	12
Configuration pin 1 (baud rate)	13
Configuration pin 2 (baud rate)	14
Configuration pin 3 (position ID)	15
Configuration pin 4 (position ID)	16
Configuration pin 5 (position ID)	17
Configuration pin 6 (position ID)	18
Reset	19
Common (COM)	20
Reserved	21
Reserved	22

3.3.3.2.1 Isolation, electrostatic discharge, filtering. Appropriate isolation, electrostatic discharge (ESD) protection and filtering shall be added to the battery communication interface to meet the requirements of 3.5.1, 3.9, and 3.10. See 4.4.2.4.2.1 for verification method.

3.3.4 Cells.

3.3.4.1 Cell shorting prevention. Each cell shall be protected from shorting or inadvertent electrical contact with other battery components. Where necessary, each cell case shall have an individual insulating coating or sleeve, or be made from an electrically insulating material. Material selected shall meet the requirements of 3.2.4.1 and 3.2.4.2. Vendor certification shall be required.

3.3.4.2 Cell leakage. No visible electrolyte leakage shall be allowed outside the cell or within the battery. Vendor certification shall be required.

3.3.5 Battery case and accessories.

3.3.5.1 Battery case. The battery case shall be capable of maintaining the specified dimensions during the life of the battery and shall be designed to prevent dimensional expansion that will prevent its removal from equipment. The battery case shall have a smooth finish free from pitting, blowholes, rough spots, or other deformations. The battery case shall be fabricated of material having sufficient strength to withstand the environmental and electrical tests specified herein, and shall be acid resistant or have an acid resistant finish or coating. When a non-metallic material is used for the battery case, the material shall be classified in accordance with UL 94, and shall be rated to 5VA classification requirements. Vendor certification for compliance with UL 94 shall be required. Materials shall be non-toxic when tested in accordance with Test Methods TO14, TO15 and TO17 of EPA/625R-96/010b. The battery top and battery bottom faces shall be parallel within 1.5 mm total. The battery case shall maintain a water-tight and air-tight seal under all test conditions specified herein. The battery case shall be one color and of the same material. To determine conformance, battery case shall be tested as specified in 4.4.2.5.1 with appropriate modifications in samples and procedures. Results shall be evaluated as specified in referenced paragraphs.

3.3.5.2 Battery accessories. The dimensions and locations of the accessories shall be as specified in figure 1 through figure 3.

3.3.5.2.1 Overpressure relief device. An overpressure relief device shall be incorporated into the battery case. The device or devices shall be located on the left, right, or both sides of the battery (see figure 3). The overpressure relief device shall not extrude greater than 8 mm from either side of the battery. This device shall be designed to release below the bursting pressure of the battery case and above the normal operating pressure of the battery. The design of the battery shall be such that the paths from the individual cell units to the battery overpressure relief device are sufficient to permit the removal of gases. The device shall prevent the entry of liquids into the battery case. To determine conformance with this requirement, test in accordance with 4.4.2.5.2.

3.3.5.2.2 Air pressure equalization port. The battery shall have a non-removable air pressure equalization port to prevent air pressure imbalance between the inside of the battery and the battery's external environment. The port shall be located on the top of the battery (see figure 1). No portion of the air pressure equalization port shall completely detach from the case. The air pressure equalization port shall withstand temperatures from -54 to 88 °C without cracking, melting or other damage. To determine conformance with this requirement, test in accordance with 4.4.2.5.3.

3.3.5.2.3 Heater(s). Heater(s) shall be incorporated into batteries if necessary to meet the cold temperature requirements. When heaters are incorporated, the following requirements shall apply (see 4.4.2.5.4):

a. The battery management system (BMS) shall automatically manage the temperature. Automated control of the heater(s) shall be activated when the master power switch is "On" in the Operational State, and when the battery is configured with the Automated Heater Function enabled.

b. Heaters shall be internally powered by the battery and be capable of being powered externally through the battery power terminals by a MIL-STD-1275 28V bus.

c. The heater shall not be operated above 10 °C ambient temperature.

d. Above 0 °C internal battery temperature, the battery shall be capable of charging (see 3.5.11), whether automated heater function is enabled or disabled.

e. All heater components shall be located inside the battery case.

f. Heater elements and wire assemblies shall be electrically insulated and installed in a manner which minimizes potential battery damage due to electrical shorting, sparking, or other electrical hazards.

g. Both primary and secondary (backup) temperature limiting controls shall be incorporated into the battery's heater electrical circuits to prevent overheating and shall be wired in series. If the primary heater control fails, the battery shall not reach a damaging temperature.

h. If the surface temperature of the battery is expected to exceed the maximum safe touch temperature as defined in MIL-STD-1472 under any normal operating condition, the battery shall include a "Caution: Hot Surface" warning label located on the top of the battery in accordance with 3.4.2.1.

3.3.5.2.4 Handles. Handles shall be fabricated from flexible material of the developed length specified in figure 6. A more rigid removable handle may be offered as an option, provided it does not exceed the length or width of the envelope of the handle attachment points on each side of the battery, nor the height of the battery case, and provided that it meets all the other physical requirements for the handles. Handles and attachments shall be undamaged after tested in accordance with 4.4.2.5.5. If knots are used to secure a plastic rope handle, the rope handles shall be attached in a manner to prevent untying, and rope ends shall be sealed to prevent fraying. The material of the handles shall be corrosion resistant to sulfuric acid, which shall be verified through engineering analysis (see 4.4.1).

3.3.6 Battle override mode. The battery shall have a battle override mode activated by the user allowing for extended operation which could otherwise degrade the battery service life (see 3.5.10), deep cycle life (see 3.5.6), and high-temperature deep cycle life (see 3.5.7) of the battery. Charging or discharging (pulse or continuous operation) of the battery within battle override shall not exceed SAE J2464 Hazard Severity Level 1. The battery shall enter battle override mode when it receives the battle override enable CAN message. When battle override mode is active, the battery's terminal cutoff voltage specified in 4.4.6.1 d shall be lowered to a battle override terminal cutoff voltage selected by the manufacturer. The battle override terminal cutoff voltage selected shall be the lowest possible terminal voltage the battery can permit based on chemistry without irreversible loss of function. The over-discharge safety protection (see 3.6.3.3 b) shall also be adjusted to account for the lower battle override terminal cutoff voltage. Additionally, when battle override mode is active, the over-temperature limit safety protection (see 3.6.3.3 d) shall be raised to the highest temperature the battery can permit based on chemistry such that thermal runaway is avoided. With battle override mode active, the battery shall maintain full functional operation. Vendor certification is required (see 4.4.2.6). Battery shall exit battle override if a battle override enable CAN message has not been received within a timeout period of 5 seconds or if the battle override disable CAN message has been received. Refer to the Appendix A of this specification for further information regarding the information on the CAN bus and its formatting.

3.4 Color and marking.

3.4.1 Battery color. The battery case color shall be in accordance with FED-STD-595/20150. The color of all visible parts of each battery, except the mounting points, hold-down hooks, other external hardware, identification marking, and instructions, shall conform to the specified color.

3.4.2 Marking, general. Identification markings shall be securely and permanently attached to the battery. Conformance shall be determined by examination and testing for the defects with standard equipment in accordance with 4.4. The front of the battery shall have a label with the information specified in 3.4.3.1 (see figure 2). The sides of the battery shall be marked with “6T Li-ion” at approximately 25 mm in height (see figure 3). The side(s) of the battery which have an overpressure relief device shall also have a label prohibiting removal of the overpressure relief device and include the warning marking of “Upon rupture, hot gases and flame may escape from this area” (see figure 2). The top of the battery shall have the following markings:

a. A specific warning label prohibiting removal of the air pressure equalization port and the communication interface (see figure 7).

b. A label with removable tabs for identifying the "in-service" date (month and year) (see figure 7).

c. The lot number in accordance with SAE AS478.

d. A label with the information specified in 3.4.3.3 (see figure 7).

3.4.2.1 Marking print and color. Each battery shall be provided with a permanent, legible hot-stamped, engraved, etched, decal, label, name plate, or case color contrasting printed marking (black or white) as specified herein and that shall be legible throughout all tests. The identification markings shall use a type size not less than 4.2 mm and the warning markings shall use a type size not less than 6.3 mm. Direct printing on the battery is the preferred method. The markings may be placed on more than one surface. Lettering shall be without serifs (sans-serif).

3.4.2.2 Permanence and durability. Markings examined on received samples and those undergoing the tests in 4.4 shall show no evidence of blistering, delamination, separation, discoloration, chipping, dissolving, softening, illegibility, corrosion, loosening, splitting, flaking, cracking, peeling, warping, or fading.

3.4.3 Identification markings.

3.4.3.1 Battery identification marking. The battery identification marking shall contain the following information. The manufacturer shall fill in the information in brackets as shown below. Abbreviations in accordance with ASME Y14.38 and acronyms are permitted. Placement of the statements shown below is flexible.

a. BATTERY, RECHARGEABLE

b. Battery Identification Lithium Ion, Non-spillable, Chemistry: [Lithium Iron Phosphate – FeP, Lithium Mixed Metal Oxide – MMO], TYPE: [1, 2, or 3]

c. Designation [Military and SAE, when applicable].

d. MIL Part No. or PIN :

e. Replaces: [Part no. and include replacement data from applicable battery specification sheet]

f. Battery Voltage: 24 Volts

g. Full Capacity Rating [_Ah] @ 1C rate:

h. Full Capacity Rating [_Wh] @ 1C rate:

i. Cranking Amps at -18 and -40 °C:

j. NSN:

k. Manufacturer's Battery Part Number:

l. Contract or Order Number:

m. Date of Manufacture and Lot Code:

n. Unique Serial Number:

o. MFG Warranty Details:

p. Manufacturer:

q. Manufacturer's CAGE code:

r. MFG Location:

s. Battery weight in pounds:

3.4.3.1.1 Date of battery manufacture and lot code. The lot code shown shall indicate the month, year, and lot number of manufacture of the battery by means of a six digit number in which the first two digits shall indicate the number of the month, the middle two digits shall indicate the year and the last two digits indicate the inspection lot number. Months earlier than the tenth month shall be a single digit preceded by "0". A forward slash "/" shall separate the first two digits from the middle two and a dash "-" shall separate the date code from the lot number. When a battery is completed during the last three working days of a month or the first three working days of the subsequent month, the manufacturer is permitted to use either month as the coded month of manufacture. For example, lot code 04/09-12 indicates the lot was compiled in April 2009 and was the twelfth lot.

3.4.3.2 Item unique identification (IUID). Batteries meeting IUID requirements (see DFARS 252.211-7003) or as specified in the contract or delivery order (see 6.2) shall be marked with IUID-compliant 2D Data Matrix symbols in accordance with MIL-STD-130. Markings shall remain legible after all tests. Markings shall be on either side of the battery. The following core IUID data elements shall be included:

a. IUID Type

b. Concatenated unique item identifier

c. Based on the IUID type, one or more of the following elements may be required:

d. Issuing agency code

e. Enterprise identification number

f. Original part, lot or batch number

g. Current part number

h. Serial number

i. Item description

j. Unit of measure

k. Contractor cage or DUNS number

l. Contract number

m. CLIN/SLIN/ELIN

n. Acquisition cost

o. Acceptance location code

p. Shipment/acceptance date

q. Ship to code

r. Formation date

s. Web link to safety data sheet (SDS)

3.4.3.3 Maintenance advisory tag. Figure 8 is an example of the maintenance advisory tag. The maintenance advisory tag shall be placed on the top of the battery (see figure 7). Unless otherwise specified in the contract, maintenance advisory marking shall include the following:

a. Marked "***RECOVERABLE ITEM***".

b. Marked "ESTIMATED 5 YEAR MINIMUM SERVICE LIFE".

c. Marked "DO NOT DISPOSE WITHOUT TESTING IAW TB".

d. Marked "DO NOT FILL/OPEN (NOT USER SERVICABLE)".

e. Marked "USE OF APPROVED TESTING AND CHARGING EQUIPMENT IS REQUIRED".

f. Marked "INSTALL DATE (MM/YYYY)". This marking shall be a box with write-in space for the install date, and shall also include removable tabs for the install date.

g. Box marked "CHECK IF RETEST FAILS". This marking shall be a box with write-in space.

h. Yellow background.

3.4.4 Instructions and notes. The back of each battery shall be marked with complete instructions for operation and charging of the battery, which shall include the following:

a. Preferred charging method

b. Alternate charging method if applicable

c. Self-discharge rate

d. Maintenance (i.e. charge periodically)

3.4.5 Warning markings.

3.4.5.1 General warning marking. The following warning markings shall appear in capital letters on the top of each battery:

a. DO NOT INSTALL LITHIUM ION BATTERIES WITH 12 VOLT LEAD ACID BATTERIES.

b. CAUTION: LITHIUM ION BATTERY. RECHARGE PER AUTHORIZED/APPROVED INSTRUCTIONS.

c. DO NOT CRUSH, MUTILATE, SHORT CIRCUIT, REVERSE POLARITY, DISASSEMBLE, BURN, OR DISPOSE OF IN TRASH.

d. IF THERE IS INDICATION OF VENTING, BURNING, BULGING, EXTREMELY HOT TO TOUCH, LOCALIZED DISCOLORATION, LEAKAGE, OR ODORS, CONTACT EMERGENCY SERVICES.

3.4.5.2 Hazard severity label. The following warning label shall appear on the top of Type 2 and 3 batteries.

a. CAUTION: DO NOT INSTALL IN VEHICLES APPROVED ONLY FOR TYPE 1 BATTERIES.

b. BATTERY CAN PRODUCE FIRE OR FLAME IF ABUSED.

The following warning label shall appear on the top of Type 1 batteries.

a. BATTERY CAN PRODUCE FIRE OR FLAME IF ABUSED.

3.5 Operating requirements.

3.5.1 Dielectric strength and insulation resistance. The battery and its components shall be tested as specified in 4.4.4. The dielectric strength or leakage current shall not be greater than 0.5 milliamperes RMS and the insulation resistance between them shall not be less than 10 megaohms. Vendor certification shall be required.

3.5.2 Operating and storage temperature range. The battery shall be required to operate over the following temperature range: -46 to 71 °C. The battery shall be capable of being stored over the following temperature range: -54 to 88 °C. See section 4.4.5 for verification.

3.5.3 Battery voltage. The operational voltage range shall comply with MIL-STD-1275, except minimum cranking voltage as defined in table I. Vendor certification shall be required.

3.5.4 Full charge capacity. Each fully charged battery shall yield a full charge capacity of not less than that specified in table I when tested in accordance with 4.4.6.1. After testing, batteries shall meet the inspection criteria of 3.19 and the dimensional and weight requirements of 3.3.2. The cell or battery temperature shall not exceed the temperature defined by the manufacturer for their battery over-temperature protection as specified in 3.11.2.4 at any time during a capacity test.

3.5.5 Cranking amps. Fully charged batteries shall be capable of maintaining cranking amps as specified in table I when tested as specified in 4.4.6.2. During the cranking tests above 0 °C, the voltage shall not drop below the cranking surge voltage as specified in MIL-STD-1275; otherwise the voltage shall not drop below the voltage specified in table I. After test, the battery shall exhibit a minimum terminal voltage as specified in 3.5.3.

3.5.6 Deep cycle life. The battery shall maintain at least 80 percent of the full charge capacity as determined in 4.4.6.3 after 1000, 100-percent depth of discharge cycles at 38±3 °C, when tested as specified in 4.4.6.3.

3.5.7 High temperature deep cycle life. The batteries shall maintain at least 80 percent of the full charge capacity as determined in 4.4.6.4 after 500, 100-percent depth of discharge cycles at 50±3 °C, when tested as specified in 4.4.6.4.

3.5.8 Retention of charge. Following not less than 90 calendar days in the Operational State (see 3.6.6.3) with the master power switch "Off" at 40 °C and -40 °C batteries shall provide pulse discharge rates specified in table I, when tested as specified in 4.4.6.5.

3.5.9 Battery storage life. Each battery shall be capable of not less than two years of warehouse storage, without any maintenance during storage, during which storage temperatures may vary between the limits of 22±5 °C. Batteries stored at 100 percent state of charge under these conditions shall not drop below 20 percent state of charge at the end of their two year shelf life, and full capacity as defined in table I shall be recoverable upon recharge. When tested in accordance with 4.4.7, battery capacity shall be at minimum 20 percent of the full capacity defined in table I, and batteries shall then meet the requirements of 3.5.4 and 3.19. The Government reserves the right to perform the 24 month shelf life test and remove the battery from the qualified products list if battery fails to meet this requirement.

3.5.10 Battery service life. The battery service life shall be five years when operated under normal conditions (see 4.3.1.1). Test in accordance with section 4.4.8.

3.5.11 Charging. Each battery shall be capable of charging from the vehicle electrical power bus defined in MIL-STD-1275. The battery shall be capable of being recharged to a minimum of 90 percent of full charge capacity within 1 hour starting from 0 percent state of charge at 22±5 °C. See 4.4.9 for verification.

3.5.12 Jump start power export. The battery when installed in a vehicle shall not prevent the vehicle from exporting power to jump start another like vehicle. The activation of safety protections (see 3.6.3.3) are not considered a failure of this requirement. Vendor certification is required. See section 4.4.10 for verification.

3.5.13 Jump start power import. The battery when installed in a vehicle shall not prevent the vehicle from importing power to allow a jump start from another like vehicle. The activation of safety protections (see 3.6.3.3) are not considered a failure of this requirement. Vendor certification is required. See section 4.4.11 for verification.

3.6 Battery management system requirements.

3.6.1 Battery management system (BMS). The battery shall contain an integrated battery management system (BMS). The BMS shall not add volume to the battery that exceeds the dimension limitations in 3.3.2. See 4.5.1 for verification.

3.6.2 BMS power. The BMS shall be powered internally from the battery's cells, and support being powered externally through the battery power terminals in case of insufficient power from the battery cells, by a MIL-STD-1275 28 V bus. Manufacturer certification shall be required. See 4.5.2 for verification method.

3.6.3 BMS features. The battery shall support all, but is not limited to, the following BMS features:

3.6.3.1 Monitoring. The battery shall be capable of measuring and communicating battery voltage, battery internal temperatures, and current into or out of the battery. The battery shall be capable of calculating and communicating state of charge (SoC), state of health (SoH), capacity (same as the amount of capacity remaining used in SoC), and time remaining. See 4.5.3.1 for verification method.

3.6.3.2 Equalization. The battery shall perform equalization to properly balance cells, strings, and modules as appropriate to maintain cell life and safety. The battery shall be capable of equalizing the cells at a minimum rate of two percent of the rated battery capacity per hour (see table I). At the end of equalization, the difference between the maximum and minimum cell voltages shall not exceed 25 mV. Manufacturer certification shall be required. See 4.5.3.2 for verification method.

3.6.3.3 Safety protections. The battery shall be protected from, but not limited to, the following conditions. See 4.5.3.3 for verification method.

a. Overcharge

b. Over-discharge

c. Over-current or short-circuit

d. Over-temperature

e. Low temperature charge protection

3.6.3.4 Enable/disable automated heaters. The battery shall accept a command on the CAN bus to enable and disable the automated heating function. Refer to the Appendix A of this specification for further information regarding messages on the CAN bus and its formatting. See 4.5.3.4 for verification method.

3.6.3.5 Contactor(s). The battery shall have a resettable subcomponent(s) with the ability to interrupt and prevent electric current flow through the battery terminals, referred to in this specification as a contactor. The contactor(s) shall be controlled automatically by the BMS. The battery shall accept a command on the CAN bus to alter the state of the contactor. Refer to the Appendix A of this specification for further information regarding messages on the CAN bus and its formatting. The contactor(s) shall be able to switch a minimum of 100,000 times. See 4.5.3.5 for verification method.

3.6.4 Communication interface. The battery shall transmit and receive messages on the CAN bus. The battery shall meet the requirements of SAE J1939. Additional information is available in ISO 11898-1, ISO 11898-2, ISO 11898-3, ISO 11898-4, and ISO 11898-5. The communication interface provides the main vehicle interface with the battery. See 4.5.4 for verification method.

3.6.4.1 Configuration pins. The battery shall use specified configuration pins as a means to configure required features. Refer to Appendix A of this specification for further information regarding the use of configuration pins. See 4.5.4.1 for verification method.

3.6.4.2 Position identity. Battery shall have a position identity. The purpose of the position identity is for the battery to determine and report the battery's position when multiple 6T Li-ion batteries are installed in the vehicle. The position identity shall be determined using configuration pins on the communication interface. Refer to the Appendix A of this specification for further information regarding the use of CAN and configuration pins on the battery communication interface. See 4.5.4.2 for verification method.

3.6.4.3 Dual CAN interfaces. The battery shall be capable of communicating on two independent CAN buses with separate interface connections. One CAN bus interface shall be primary, and the other secondary. Refer to the Appendix A of this specification for further information regarding the use of the battery CAN communication interfaces. See 4.5.4.3 for verification method.

3.6.4.4 Baud rate. The primary and secondary CAN buses interfaces of the battery shall be able to communicate at a selectable rate of 250 Kbps, 500 Kbps, and 1 Mbps determined using configuration pins on the communication interface. Refer to the Appendix A of this specification for further information regarding the use of CAN and configuration pins on the battery communication interface. See 4.5.4.4 for verification method.

3.6.4.5 NAME. The battery shall be able to communicate the SAE J1939 NAME on the CAN bus in accordance with SAE J1939. The battery shall support modifying the fields of the battery NAME in maintenance state using the NAME management (NM) message. The

NAME function instance field shall be equal to the position identity value (see 3.6.4.2) by default. See 4.5.4.5 for verification method.

3.6.4.6 Preferred source address. The battery shall use a preferred source address based on its position identity, as show in table III. See 4.5.4.6 for verification method.

TABLE III. Preferred source addresses.

Position identity	Source address
0	246
1	245
2	244
3	243
4	242
5	241
6	240
7	239
8	238
9	237
10	236
11	235
12	234
13	233
14	232
15	254

3.6.4.6.1 Arbitrary address capable. The battery shall be arbitrary address capable as specified in SAE J1939. The battery shall also allow enabling or disabling arbitrary address capability using the NM message in accordance with SAE J1939-81, and update the NAME arbitrary address capable field accordingly. See 4.5.4.6.1 for verification method.

3.6.4.6.2 Service configurable source address. The battery shall use a service configurable source address that can be configured by the commanded address (CA) message as the preferred source address in the Maintenance State. When a commanded address message is received on the CAN bus to change the preferred source address, the battery shall disable arbitrary address capability and update the NAME arbitrary address capable field. Refer to the Appendix A of this specification for further information regarding the information on the CAN bus and its formatting. See 4.5.4.6.2 for verification method.

3.6.4.7 Termination resistance. The battery shall not be required to be the terminating device or provide a termination resistance on the CAN bus interfaces. See 4.5.4.7 for verification method.

3.6.4.8 Firmware update over CAN bus. In the Maintenance State, the battery shall allow full firmware update on the CAN bus. The battery firmware update method shall be able to be performed while battery is connected to a vehicle CAN bus. The update procedure shall not require the battery to be disconnected from the vehicle CAN bus. The time needed to transmit the firmware over the CAN bus shall not exceed 15 minutes. See 4.5.4.8 for verification method. See Appendix A for more information regarding firmware updates.

3.6.5 Monitoring performance characteristics. The performance characteristics of the battery are listed in table IV.

TABLE IV. Performance characteristics.

Data	Range	Resolution	Error	Notes
State of charge (%)	0 to 100	0.5	±5 SOC	100 = fully charged 0 = empty
State of health (%)	0 to 100	0.5	±5 SOH	100 = fully healthy 0 = unhealthy
Capacity (Ah)	0 to 250	1	±3	Calculated full capacity of the battery at present conditions at the 1C rate.
Battery voltage (V)	0 to 33	0.05	±0.1	
Battery current (A)	0 to ±1,600	0.05	0 to 400±1 > 400±5	+ value = battery charging - value = battery discharging
Internal battery temperature (˚C)	-55 to 105	1	±1	Convert and report also in ˚F.
Time remaining (hours)	0 – 60 (discharge only)	0.1	N/A	
Bus voltage request (V)	0 to 33	0.05	N/A	Requested voltage for charging the battery.
Open circuit voltage (V)	0 to 33	0.05	±1	Predicted open circuit voltage, under load.
Battery power capability prediction for 10 and 30 seconds (W)	0 to 64255	1	NA	Prediction for maximum discharge power the battery can sustain for 10 and 30 seconds while maintaining voltage greater than the battery's terminal cutoff voltage specified in 4.4.6.1 d.

3.6.5.1 Calculated parameters. The battery shall compute and report the following calculated parameters on the CAN bus once every 15 seconds. The battery shall allow disabling or enabling regular interval messaging in Maintenance State, with regular interval messaging enabled by default. The battery shall also be able to report all calculated parameters on the CAN bus when a request (RQST) message is received. When request messages are received at a rate greater than once every 15 seconds for a message containing calculated parameters, the battery shall transmit values from the most recent calculation iteration on the CAN bus. Requests for calculated parameters shall not be made at a rate greater than once every one second. The battery shall calculate and transmit the Battery Power Capability Prediction message on the CAN bus at a maximum of once every one second when made by a request message, or calculate and transmit on the CAN bus at a selectable message interval rate from 1 second to 15 seconds. Refer to the Appendix A of this specification for further information regarding the data available on the CAN bus and its formatting. See 4.5.5.1 for verification method.

3.6.5.1.1 State of charge (percent). The state of charge shall be communicated on the CAN bus. See table IV for accuracy requirement. See 4.5.5.1.1 for verification method.

3.6.5.1.2 State of health (percent). The state of health shall be communicated on the CAN bus. See table IV for accuracy requirement. See 4.5.5.1.2 for verification method.

3.6.5.1.3 Capacity estimation. The calculated full capacity of the battery at present conditions at the 1C rate shall be communicated on the CAN bus. See table IV for accuracy requirement. See 4.5.5.1.3 for verification method.

3.6.5.1.4 Time remaining (at present rate of discharge). The time remaining shall be communicated on the CAN bus. See table IV for accuracy requirement. See 4.5.5.1.4 for verification method.

3.6.5.1.5 Bus voltage request (for charging). The bus voltage request shall be communicated on the CAN bus. See 4.5.5.1.5 for verification method.

3.6.5.1.6 Open circuit voltage. The open circuit voltage shall be communicated on the CAN bus. See table IV for accuracy requirement. See 4.5.5.1.6 for verification method.

3.6.5.1.7 Battery power capability prediction. The battery shall calculate and communicate on the CAN bus the maximum discharge power predictions in watts that the battery can sustain for 10 and 30 seconds while maintaining a voltage above the battery's terminal cutoff voltage specified in 4.4.6.1 d. See table IV for accuracy requirement. See 4.5.5.1.7 for verification method.

3.6.5.2 Measured parameters. The battery shall measure and report the following measured parameters on the CAN bus at a selectable message interval rate from 1 second to 15 seconds. The interval rate shall be configurable via CAN message when battery is in Maintenance State, with one second interval rate by default. The battery shall allow disabling or enabling recurring interval messaging in Maintenance State, with regular interval messaging enabled by default. The battery shall also be able to report measured parameters on the CAN bus when a request message is received, which shall not be made at a rate greater than once every one seconds. Refer to the Appendix A of this specification for further information regarding the information on the CAN bus and its formatting. See 4.5.5.2 for verification method.

3.6.5.2.1 Battery voltage (V). Battery voltage shall be in accordance with table IV. See 4.5.5.2.1 for verification method.

3.6.5.2.2 Battery current (A). Battery current shall be in accordance with table IV. See 4.5.5.2.2 for verification method.

3.6.5.2.3 Internal battery temperature (°C). Internal battery temperature shall be in accordance with table IV. See 4.5.5.2.3 for verification method.

3.6.5.2.4 Celsius and Fahrenheit support. Measured parameters containing temperature data shall support reporting in Celsius and Fahrenheit. Refer to the Appendix A of this specification for further information regarding the information on the CAN bus and its formatting. See 4.5.5.2.4 for verification method.

3.6.5.3 Manufacturer specific parameters. For reported parameters other than the ones specified in 3.6.5.1 and 3.6.5.2, the parameters shall be reported on the CAN bus at a selectable rate from 1 second to 15 seconds. The interval rate shall be configurable for each Parameter Group via CAN message when battery is in Maintenance State, with 15 second interval rate by default. The BMS shall allow disabling or enabling regular interval messaging in Maintenance State, with regular interval messaging enabled by default. The battery shall also be able to report manufacturer specific parameters on the CAN bus when a request message is received, which shall not be made at a rate greater than once every one second. Examples of manufacturer specific parameters are cell voltages (individual, average, minimum, maximum), temperatures (individual, average, minimum, maximum) other than internal battery temperature (such as cell temperature, BMS temperature, contactor temperature, etc.), equalization parameters, built-in test (BIT) results, manufacturer specific battery configuration messages, etc. CAN messages for manufacturer specific parameters shall be defined by the battery manufacturer in the address space permitted. Refer to the Appendix A of this specification for further information regarding the information available on the CAN bus and its formatting. See 4.5.5.3 for verification method.

3.6.5.3.1 Cell voltages. The battery shall report the values of cell voltages on the CAN bus. Cell voltage shall be provided for all individual cells, and shall be a reported as a differential value. Cells at the same potential due to parallel electrical connection are permitted to be measured and reported as a single grouped cell. See 4.5.5.3.1 for verification method.

3.6.5.3.2 Equalization. The battery shall report the status of battery equalization (see 3.6.3.2) on the CAN bus. Information reported shall include state of equalization (such as on/off) for each cell (or group of parallel connected cells), and the maximum and minimum difference between the individual cell (or group of parallel connected cells) voltages in the battery. See 4.5.5.3.2 for verification method.

3.6.5.3.3 Built-in test (BIT) results. The battery shall report BIT results on the CAN bus in accordance with 3.6.7. Faults and failures shall be communicated in the form of diagnostic trouble code (DTC) messages in accordance with SAE J1939 on the CAN bus. See 4.5.5.3.3 for verification method.

3.6.5.3.4 Celsius support. Manufacturer Specific messages containing temperature data shall be reported in Celsius. Refer to the Appendix A of this specification for further information regarding the information on the CAN bus and its formatting. See 4.5.5.3.4 for verification method.

3.6.6 Battery states.

3.6.6.1 Dormant (off) state. The battery shall have a Dormant State for long term storage. The Dormant State shall be activated and deactivated by the dormant pins on the communication interface. The transition time to or from the Dormant State shall not exceed 10 seconds. The battery terminals shall not provide electrical power to external loads while in the Dormant State. The battery shall enter the Dormant State if there is insufficient power to operate the BMS, and exit the Dormant State if the dormant pins are connected and there is sufficient power available on the battery terminals from an external power source. Refer to Appendix A for further information regarding the communication interface. See 4.5.6.1 for verification method.

3.6.6.2 Initialize state. Upon exiting the Dormant State, the battery shall enter the Initialize State. The time to execute initialization and transition to the Operational State shall not exceed 10 seconds. The battery shall run a power-up built-in test (PBIT) at least once during the Initialize State and store the results. See 4.5.6.2 for verification method.

3.6.6.3 Operational state. The battery shall be in the Operational State upon exiting the Initialize State. In the Operational State, the battery shall report the battery's parameters with a regular interval when the master power switch is "On". In the Operational State, the battery shall report the battery's parameters in response to a RQST message. The battery shall not report CAN messages with a regular interval when the master power switch is "Off". The battery shall accept Configuration Messages while in the Operational State, but shall only permit configuration parameter changes that are allowed outside the Maintenance State. When entering the Operational State and the master power switch is "On", or while in the Operational State and the master power switch changes from "Off" to "On", the battery shall report CAN messages with battery voltage, battery current, battery internal temperature, state of charge, state of health, capacity estimation, time remaining, and BIT results and complete transmission in a time not to exceed 500 milliseconds on the CAN bus that is open for transmission. If calculated parameters cannot be calculated within this time period, the battery shall report the values from the most recent measurement cycle. Measurement and calculation of the battery's parameters shall occur as often as necessary to track changes in battery condition, comply with the measurement accuracy specified in table IV, update and report battery parameters for CAN communication, and comply with Battery Safety 3.11.2. The battery shall run continuous built-in test (CBIT) as often as necessary to comply with 3.6.7, and CBIT execution shall not interfere with the normal operation of the battery. The battery terminals shall always be able to provide electrical power to external loads while in the Operational State, except when the battery configuration message is sent with "Command Contactor(s)" parameter set to "Open Contactor(s)" is received on the CAN bus. The battery shall remain in the Operational State as long as the battery voltage is in the acceptable range (see 3.5.3) and safety limits have not been exceeded. See 4.5.6.3 for verification method.

3.6.6.4 Maintenance state. The battery shall enter the Maintenance State when it receives the Maintenance State command on the CAN bus. The Maintenance State shall have a firmware update capability. The Maintenance State shall accept and execute Configuration messages transferred over the CAN bus, including configuration parameters that are only permitted when the battery is in the Maintenance State. The battery shall exit the Maintenance State when it receives the Exit Maintenance State command over the CAN bus, or timeout of five minutes occurs since the last CAN message addressed to battery was sent. See 4.5.6.4 for verification method.

3.6.6.5 Protected state. The battery shall enter the Protected State when a condition occurs that may cause the battery to operate outside its safety protections (see 3.6.3.3). The battery shall not provide electrical power at the battery's terminals to external loads when in the Protected State. The battery shall send out warning and other information regarding the Protected State over the CAN bus according to Appendix A. The battery shall communicate this information before transitioning to the Protected State, when doing so does not present a safety hazard. The battery shall communicate any applicable faults using diagnostic trouble codes (DTCs). The battery shall transition out of the Protected State when the battery senses that the fault condition has been removed. For faults that cannot be removed automatically or for faults that have a timeout period, the battery shall attempt to transition out of the Protected State when the battery configuration message parameter "Reset" has a value of "Reset Protection", or if the master power switch changes from "Off" to "On". Figure 9 is a visual representation of the battery state map. See 4.5.6.5 for verification method. Faults requiring a timeout period in excess of 30 seconds shall require approval by Government qualification authority.

3.6.7 Built-in tests. The battery shall have provisions to perform built-in tests (BIT) to indicate that the battery and its subsystems are operating properly. BIT shall be performed by means as described below. The battery state of health and state of charge shall be checked when the BIT is performed. BIT diagnostics shall be capable of isolating faults and failures at least to the following ambiguity groups: cells, sensors or battery management system.

3.6.7.1 Power-up BIT. PBIT shall execute automatically as the battery enters the Initialize State. The PBIT shall execute within the time duration of the Initialize State (3.6.6.2). See 4.5.7.1 for verification method.

3.6.7.2 Continuous BIT. CBIT shall periodically run under BMS control. CBIT shall not degrade the performance of the battery. See 4.5.7.2 for verification method.

3.6.7.3 BIT diagnostics probability. BIT diagnostics shall meet 95 percent probability of detecting all battery faults. Manufacturer certification shall be required. See 4.5.7.3 for verification method.

3.6.8 Long term fault data storage (non-volatile). Long term data recording of battery fault data shall be stored in non-volatile memory. Long term fault data storage shall support recording critical fault data to support a mission of 96 hours. See 4.5.8 for verification method.

3.6.9 Short term fault data storage (volatile). Short term fault data shall be stored in volatile memory. See 4.5.9 for verification method.

3.7 Surges, spikes, and disturbances.

3.7.1 Voltage surges. Voltage surges exported and imported by the battery shall be within the limits specified in MIL-STD-1275. The battery shall not cause any excursion outside these limits nor cause damage to other equipment designed to tolerate transients within these limits nor be damaged by surges within these limits. See 4.6.1 for verification method.

3.7.2 Voltage spikes. Voltage spikes exported and imported by the battery shall be within the limits specified in MIL-STD-1275. The battery shall not cause any excursion outside exported limits nor cause damage to other equipment designed to tolerate transients within these limits nor be damaged by spikes within imported limits. See 4.6.2 for verification method.

3.7.3 Starting disturbance. Starting disturbances exported and imported by the battery shall be within the limits specified in MIL-STD-1275. The battery shall not cause any excursion outside these limits nor cause damage to other equipment designed to tolerate transients within these limits. See 4.6.3 for verification method.

3.7.3.1 Starting current. The battery shall be capable of providing, at a minimum, the starting current shown in figure 10. See 4.6.4 for verification method.

3.7.4 Steady state surges. Surge transients exported and imported by the battery shall be within the limits specified in MIL-STD-1275. The battery shall not cause any excursion outside exported limits nor cause damage to other equipment designed to tolerate transients within these limits nor be damaged by surge transients within imported limits. See 4.6.5 for verification method.

3.7.5 Steady state spikes. Spike transients exported and imported by the battery shall be within the limits specified in MIL-STD-1275. The battery shall not cause any excursion outside exported limits, nor cause damage to other equipment designed to tolerate transients within these limits, nor be damaged by surge transients within imported limits. See 4.6.6 for verification method.

3.8 Environmental. After being subjected to the environmental tests listed in table V, the battery shall meet the visual and mechanical inspection criteria defined in 3.19 and the full charge capacity requirement defined in 3.5.4. The battery in its fully charged state shall meet the battery voltage requirements as defined in 3.5.3.

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TABLE V. Environmental requirements.

Tests	Test paragraph
Low pressure, altitude	4.7.1.1
Rapid decompression	4.7.1.2
Attitude	4.7.2
Thermal shock	4.7.3
Mechanical shock	4.7.4
Vibration	4.7.5
Immersion	4.7.6
Humidity	4.7.7
Blowing dust	4.7.8
Salt atmosphere	4.7.9
Fluid susceptibility	4.7.10
Explosive atmosphere	4.7.11

NOTE: A charge/discharge cycle of the battery shall be performed before and after each environmental test to determine whether the test had a negative impact on the performance of the battery.

3.8.1 Altitude.

3.8.1.1 Altitude, operating & non-operating. When tested as specified in 4.7.1.1, the battery shall meet the requirements defined in 3.8. The battery shall not have mass loss of greater than 0.5 percent after completion of the tests.

3.8.1.2 Rapid decompression. When tested as specified in 4.7.1.2, the battery shall meet the requirements defined in 3.8. The battery shall not have mass loss of greater than 0.5 percent after completion of the test.

3.8.2 Attitude. When tested as specified in 4.7.2, the battery shall meet the requirements defined in 3.8. The battery shall be designed for operation in any orientation.

3.8.3 Thermal shock. The battery shall be designed to withstand rapid temperature cycling between 88 °C and -54 °C. When tested in accordance with 4.7.3, the battery shall meet the visual and mechanical inspection criteria defined in 3.19, and its full charge capacity shall not decrease more than 10 percent from the full charge capacity at the start of the test.

3.8.4 Mechanical shock. When tested as specified in 4.7.4, the battery shall meet the requirements defined in 3.8.

3.8.5 Vibration. Cells, batteries, and connectors shall be capable of withstanding vibration environments without sustaining physical or electrical damage. Batteries shall maintain a steady voltage and current without loosening of terminal posts, electrolyte/cell leakage; broken connections; damage to wiring, circuit boards, or BMS operations; straps or cells; movement or disassembly of cells; any smoking or evidence of thermal instability; or other damage. When tested as specified in 4.7.5, the battery shall meet the requirements defined in 3.8.

3.8.6 Immersion. The battery shall be designed to withstand complete water immersion. When tested in accordance with 4.7.6, the battery shall meet the requirements defined in 3.8. In addition, it shall show no evidence of leakage of water into cases, and shall exhibit weight gain of not greater than 0.1 percent.

3.8.7 Humidity. The battery shall be capable of operating at a relative humidity from 0 percent to 100 percent including condensation. When tested in accordance with 4.7.7, it shall meet the requirements defined in 3.8. The battery capacity shall not degrade more than three percent from the start of the test.

3.8.8 Blowing sand and dust. When tested in accordance with 4.7.8, the battery shall meet the requirements defined in 3.8.

3.8.9 Salt atmosphere. When tested in accordance with 4.7.9, the battery shall meet the requirements defined in 3.8. Capacities measured before and after test shall be within three percent of each other.

3.8.10 Fluid susceptibility. When tested in accordance with 4.7.10, the battery shall meet the requirements defined in 3.8. Capacities measured before and after test shall be within three percent of each other.

3.8.11 Explosive atmosphere. The battery shall be able to successfully pass the test defined in 4.7.11.

3.9 Electromagnetic compatibility/interference. When tested in accordance with 4.8, the battery shall meet the requirements of CE 102, CS 101, CS 114, CS 115, CS 116, RE 102, and RS 103 of MIL-STD-461. Capacities measured before and after test shall be within three percent of each other. Vendor certification shall be required for compliance to applicable requirements of MIL-STD-464 once the batteries are placed in a system.

3.10 Electrostatic discharge. Batteries shall withstand ESD to ±8 kV contact discharge or an air discharge of ±15 kV from a 150 picofarad capacitor source through a 330 ohm resistor in accordance with IEC 61000-4-2 on any surface, panel component or connector, including exposed pins, in both operating and non-operating mode. See test defined in 4.9.

3.11 Safety.

3.11.1 Cell safety.

3.11.1.1 Cell safety abuse tests. The cell shall be characterized in accordance with SAE J2464 and the corresponding Hazard Severity Level reported to the Government. See 4.10.1.1 for verification method.

3.11.1.1.1 Cell overcharge. Cell shall be characterized in accordance with the Overcharge Test (Cell and Module or Pack) section of SAE J2464. See 4.10.1.1.1 for verification method.

3.11.1.1.2 Cell short circuit. Cell shall be characterized in accordance with the Short Circuit Tests (Cell and Module or Pack) section of SAE J2464. See 4.10.1.1.2 for verification method.

3.11.1.1.3 Cell overdischarge. Cell shall be characterized in accordance with the Overdischarge (Forced Discharge) Test (Cell Level and Module) section of SAE J2464. See 4.10.1.1.3 for verification method.

3.11.1.1.4 Cell penetration. Cell shall be characterized in accordance with the Penetration Test (Cell Level or above) section of SAE J2464. Characterization shall be performed at a minimum of 100 percent state of charge, and at 50 percent state of charge. See 4.10.1.1.4 for verification method.

3.11.1.1.5 Cell crush. Cell shall be characterized in accordance with the Crush Test (Cell Level or above) section of SAE J2464. See 4.10.1.1.5 for verification method.

3.11.1.2 Cell leakage. Cells used to build batteries shall not be subject to leakage in storage or use. After testing, cells shall not exhibit leakage indicated by presence of liquid, or solid deposits; additionally, mass loss of test samples shall be not greater than 0.1 percent. See 4.10.1.2 for verification method.

3.11.2 Battery Safety.

3.11.2.1 Battery over-current protection. When tested in accordance with 4.10.2.1, the battery shall meet the visual and mechanical inspection criteria defined in 3.19 and the full charge capacity requirement defined in 3.5.4. Capacities measured before and after test shall be within three percent of each other. The battery shall meet the open circuit voltage requirement of 3.5.3 upon removal of the short circuit.

3.11.2.2 Battery overcharge.

3.11.2.2.1 Overcharge abuse.

a. Type 1. When battery is overcharged according to S9310-AQ-SAF-010 test with BMS safety protections (see 3.6.3.3) bypassed, the battery shall not exceed Hazard Severity Level 4.

b. Type 2 and Type 3. When battery is overcharged according to S9310-AQ-SAF-010 test with BMS safety protections (see 3.6.3.3) bypassed, the battery shall not exceed Hazard Severity Level 6.

3.11.2.2.2 Overcharge protection. With BMS active and not bypassed, batteries shall be capable of withstanding overcharge conditions. When tested as specified in 4.10.2.2, batteries shall not exceed the voltage limit specified in 3.5.3. Additionally, before and after test, the full charge capacities shall be within three percent of each other.

3.11.2.3 Battery over-discharge protection. Batteries shall provide protection against over-discharge conditions without burning, disassembly, or other failure. When tested as specified in 4.10.2.3 batteries shall not exceed the voltage limit specified in 3.5.3 during over-discharge. Additionally, before and after test, the full charge capacities shall be within three percent of each other.

3.11.2.4 Battery over temperature protection. Each battery shall prevent operation when the battery exceeds temperature defined by manufacturer to ensure safety under conditions of high temperature, overcharge, misuse, or any combination thereof. When tested as specified in 4.10.2.4 the batteries shall meet the capacity requirement of 3.5.4 after reaching the cool down temperature.

3.11.2.5 Battery low temperature charge protection. Each battery shall prevent charging at a temperature which would degrade battery safety or life. When tested as specified in 4.10.2.5 the batteries shall meet the capacity requirement of 3.5.4 after reaching safe charge temperature.

3.11.2.6 Battery impact resistance (non-metallic battery case only). When tested as specified in 4.10.2.6 the empty and sealed nonmetallic battery case shall meet the requirements of 3.3.1.1

3.11.2.7 Battery abuse.

3.11.2.7.1 Battery crush.

a. Type 1. Battery shall be characterized in accordance with the Crush Test (Cell Level or above) section of SAE J2464, and shall not exceed a Hazard Severity Level 4. See 4.10.2.7.1 for verification method.

b. Type 2 and Type 3. Battery shall be characterized in accordance with the Crush Test (Cell Level or above) section of SAE J2464, and shall not exceed a Hazard Severity Level 6. See 4.10.2.7.1 for verification method.

3.11.2.7.2 Battery penetration.

a. Type 1. Batteries shall not exceed SAE J2464 Hazard Severity Level 4 when their battery cases are penetrated by nail. Batteries shall not exceed SAE J2464 Hazard Severity Level 6 when their battery cases are penetrated by projectile. During projectile penetration testing, the battery shall fail to meet this requirement if Hazard Severity Level is exceeded during testing. See 4.10.2.7.2 for verification method.

b. Type 2 and Type 3. Batteries shall not exceed SAE J2464 Hazard Severity Level 6 when their battery cases are penetrated by nail. Batteries shall not exceed SAE J2464 Hazard Severity Level 6 when their battery cases are penetrated by projectile. During projectile penetration testing, the battery shall fail to meet this requirement if Hazard Severity Level is exceeded during testing. See 4.10.2.7.2 for verification method.

3.11.2.7.3 Battery drop low height. The battery shall be capable of withstanding drops at extreme temperature conditions. When tested in accordance with 4.10.2.7.3, the batteries shall meet the inspection criteria defined in 3.19 and the full charge capacity requirements defined in 3.5.4. Full charge capacities before and after the test shall be within three percent of each other.

3.11.2.7.4 Battery drop high height. The battery shall not exceed SAE J2464 Hazard Severity Level 2 when dropped at extreme temperature conditions. Cell leakage as defined by SAE J2464 Hazard Severity Level 3 is acceptable when confined to the battery case. Venting is not allowed. See 4.10.2.7.4 for verification method.

3.12 Lithium battery safety program (U.S. Navy). The battery shall be evaluated under Navy S9310-AQ-SAF-010 safety testing and be certified as transportable on Navy vessels. See 4.11 for verification method.

3.13 Charger compatibility. Batteries shall be capable of correctly powering and interfacing with MIL-STD-1275 compliant systems and chargers (see 4.12).

3.14 Workmanship. Batteries shall be processed in such a manner as to be free from cracked or displaced parts, sharp edges, burrs, and other defects which will affect life, serviceability, or appearance (see 4.13).

3.15 Product characteristics.

3.15.1 Paint, protective finishes, and coatings. Protective finishes shall be in accordance with MIL-STD-171. Application of chemical agent resistive coating (CARC) paint shall be in accordance with drawing 12350824. Zinc phosphate shall be sprayed to bare metal surfaces (Rockwell Hardness C48 and over) prior to painting, to promote paint adhesion. The battery case color shall be FED-STD-595/20150. See 4.14.1 for verification method.

3.15.2 Corrosion resistance. Metals and alloys used in the battery that are exposed to corrosive environmental conditions shall be corrosion resistant or metallurgically processed to resist corrosion. Dissimilar metal combinations that promote corrosion through galvanic action shall be insulated to prevent corrosion. See 4.14.2 for verification method.

3.15.3 Restricted materials. The battery shall be produced according to the restrictions listed in 3.16 and 3.17.

3.16 Electronic assemblies.

3.16.1 Electronic assembly acceptability. Electronic assemblies in the battery shall be constructed to meet IPC-A-610 and IPC J-STD-001 Class 3 acceptability requirements. See 4.15 for verification method.

3.16.2 Lead-free control plan. When specified in the contract or order (see 6.2), a lead-free control plan (LFCP) shall be submitted to the vehicle integrator for approval. GEIA-STD-0005-1 or an equivalent shall be used as a basis for preparation of a LFCP. The plan shall address all solders and lead-free finishes in delivered item. See 4.15 for verification method.

3.16.3 Lead-free risk management. The battery shall use lead-free solder finishes. Finishes shall be selected such that harmful effects of tin whiskers resulting from use of lead-free solder shall be addressed and mitigated in accordance with GEIA-STD-0005-2. At a minimum the following mitigations shall be employed when using lead-free solder. See 4.15 for verification method.

a. Level 2B risk mitigation strategy.

b. Maintain minimum conductor spacing of >457 microns (typically greater than 25 mil pitch).

c. Use conformal coating. The following coatings are listed in order of perceived effectiveness for tin whisker mitigation: Parylene, UR, AR, SR.

d. If unable to obtain leaded component with spacing of at least 457 microns then:

(1) Pure tin finishes with <457 micron conductor spacing shall be hot solder dipped in accordance with GEIA-STD-0006.
(2) Non tin or tin alloy finishes with <457 micron conductor spacing need to be approved by the contracting agency

3.16.4 Notification. It shall be the responsibility of the contractor to document all lead-free parts used (including, but not limited to: termination materials and finishes, printed wiring board finishes, and assembly materials). This documentation shall be provided to the Government upon request.

3.17 Hazardous materials. Asbestos, beryllium, radioactive materials, hexavalent chromium, cadmium, mercury, or other highly toxic or carcinogenic materials, as defined in 29 CFR 1910.1200, with the exception of the chemical agent resistant coating (CARC) or if non-hazardous/non-toxic substitute material will not meet performance requirements, shall not be used in the manufacture, assembly, operation or sustainment of this system without prior approval from the Government (see 6.2). Approval will only be granted when valid technical justification is provided. Class I and Class II ozone depleting substances shall not be used. Lead shall not be used without prior approval of the Government. The use of eutectic tin lead solders (Sn60 or Sn63) may be approved for electrical assemblies where a suitable lead-free alternative is not available. Hazardous materials requirements shall apply to any components or parts purchased through a subcontractor or vendor or OEM parts, as well as manufactured parts. See 4.16 for verification method.

3.18 Chemical, biological, radiological and nuclear (CBRN). The exterior surfaces of the battery shall be decontaminable using the procedures and decontaminants identified in FM 3-11.5 to negligible risk levels identified in ATPD 2404 after thorough decontamination. See 4.17 for verification method.

3.19 Defects. The battery shall be free of any defects during incoming or post-test visual and mechanical inspections (see 4.4.2.1, 4.4.2.2 and table VI). It is recommended that contracts allow defects in categories 003, 007, 009, 102, 103, 104, 105, 106, 107, 201, and 202 of table VI be permitted to be reworked during PPI inspection (see 6.2).

TABLE VI. Visual and mechanical inspection.

Categories (see note)	Applicable to incoming (see 4.4.2.1) or post-test (see 4.4.2.2) inspection	Defects
001	Both	Electrolyte leakage, outside or detectable within the battery.
002	Incoming	Improper molding or assembly causing parts to be inoperative or unsafe in service.
003	Both	Insulation missing or damaged.
004	Both	Crazing of glass in glass to metal seals.
005	Both	Foreign material particles in insulation, potting, or sealing compounds.
006	Post-test	Explosion, flame, fire, venting of solid material, disassembly, cell leakage, or rupture of cell or battery within 24 hours after the completion of the test.
007	Both	Improper operation of safety devices.
008	Both	Abnormal current or voltage fluctuations during any test. Degradation of electrical performance beyond limits specified by the test requirements, if applicable.
009	Both	Loose contacts or parts in battery.
101	Both	Deformed (beyond the specified dimensional limit), damaged or failed parts which are inoperative or malfunction in service.

TABLE VI. Visual and mechanical inspection - Continued.

Categories (see note)	Applicable to incoming (see 4.4.2.1) or post-test (see 4.4.2.2) inspection	Defects
102	Both	Contact surfaces obstructed so that electrical use is affected. Rust, corrosion, or any type of non-conductive material on contact surfaces.
103	Incoming	Cell or Battery cases: any scratch, gouge, dent, pitting, blowholes, rough spots, burrs, or other deformations on battery surface or in welds.
104	Both	Improper case closure: any gap along glued or welded seams.
105	Incoming	Terminal markings, identification label or operating instructions not as specified (see 3.4.2, 3.4.3, 3.4.3.3, and 3.4.3.2).
106	Both	Marking defects are visible (see 3.4.2).
107	Both	Battery's normal attachment points (i.e. brackets, flanges, or hold down bars, etc.) shall keep the entire battery intact in the test fixture or final intended assembly.
108	Both	Breakdown of insulation, flashover, arcing, stripping of metal plating from any component part, corrosion of metal parts, or loosening of protective coating from the battery case.
109	Post-test	Marking, scaling, pitting, corrosion, charring, discolored areas, or other deleterious effects on internal and/or external parts of the cell or battery
201	Incoming	Color not as specified.
202	Both	Peeling, flaking, or chipping of plating or finish.

NOTE: Category 0XX defects are critical; category 1XX are major, and category 2XX are minor. These categories are used to qualify the levels of nonconformance. Critical defects affect safety; major defect categories affect use, batteries with minor defects may be serviceable with limitations.

4. VERIFICATION

4.1 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Qualification inspection (see 4.1.1).

b. Conformance inspection (see 4.1.2).

(1) Initial product inspection (IPI) (see 4.1.2.1).
(2) Periodic production inspection (PPI) (see 4.1.2.2)

4.1.1 Qualification inspection. Qualification inspection for inclusion on the qualified products list (QPL) shall be performed at a laboratory acceptable to the Government. The contractor shall submit sample units produced with same equipment and procedures used in production. Qualification testing shall consist of the following:

a. Sample cells, sample batteries, modified sample batteries, electronic component assemblies, and any component parts shall be submitted for testing in the quantity specified in table VII.

b. Qualification samples shall be subjected to the tests specified in table VII. The qualification samples shall consist of 13 battery samples, 5 case samples (9 case samples if case is non-metallic), 1 weighted case sample, and 15 Navy battery samples. Additionally, four battery samples shall be provided as spares.

4.1.1.1 Nonconformance (failures). Nonconformance to any specified requirement, the failure of any test, or the presence of one or more defects shall be cause for rejection and constitute failure of qualification inspection and prohibit incorporation of product into any QPL.

4.1.1.2 Successful qualification inspection. Unless otherwise specified in a contract or purchase order, the successful completion and approval by the Government of qualification inspection does not relieve a prospective contractor from required samples and initial production inspection (IPI) requirements from the first production lot using production design, tooling, and processes, at a location designated or approved by the qualification authority (see 3.1 and 6.4).

4.1.2 Conformance inspection.

4.1.2.1 Initial production inspection (IPI). Unless otherwise specified in the contract or order (see 6.2) the contractor shall perform all IPI tests and inspections on production batteries consisting of test samples from the first production lot using production design, tooling, and processes, at a place designated or approved by the qualification authority having approval and waiver authority. Quantities and component parts shall be as specified in table VII. IPI shall be conducted in accordance with the test requirements specified in table VII, assignment of test samples specified in table VII, and the descriptive paragraphs in section 4 of this specification.

Nonconformance to any specified requirement of this specification, the failure of any test, or the presence of one or more defects shall be cause for rejection.

a. The order of testing for IPI shall be established by the contractor and shall be approved by the Army qualification authority prior to start of any testing by the contractor. Advance planning and provisions shall be made to insure that each item of the test schedule and sequence shall not have a detrimental effect or preclude the performance of a subsequent test/examination on any test sample.

b. Appropriate advance notice of the test schedule, location(s), or changes shall be provided to the Government, contractor, designated test site/facility, and regulatory agency personnel to allow participation or oversight by each.

4.1.2.2 Periodic production inspection (PPI). PPI shall be done by the contractor in accordance with table VII (with Government oversight).

4.1.2.2.1 PPI general requirements. Examination and testing for each lot shall be completed no later than 21 days from the final day of manufacture of the lot.

4.1.2.2.2 PPI failures. Failure of any sample during examination or testing may be cause for the Government to refuse to accept that lot, and subsequent lots, until it has been proven to the Government's satisfaction that appropriate corrective actions have been implemented.

TABLE VII. Inspection requirements.

Inspection	Requirement paragraph	Test method paragraph	Qual	Conformance		Sample assignment[1]
				IPI	PPI	
Metals	3.2.2	Vendor Cert	X	X		B1-B13 (all)
Dissimilar metals	3.2.3	Vendor Cert	X	X		B1-B13 (all)
Potting/sealing compounds, flow and shrinkage	3.2.4.1.1	Vendor Cert (4.4.3)	X	X		B1-B13 (all)
Insulating compounds for electrical connectors, wires, and tabs	3.2.4.1.2	Vendor Cert	X	X		B1-B13 (all)
Elastomeric materials	3.2.4.2	Vendor Cert	X	X		B1-B13 (all)
Physical characteristics	3.3.1	4.4.2	X	X	X	B1-B13 (all)
Dimensions and weights	3.3.2	4.4.2.3	X	X	X	B1-B13 (all)
Terminal posts and threaded sockets	3.3.3.1	4.4.2.4.1	X	X	X	B8/9
Communication interface	3.3.3.2	4.4.2.4.2	X	X		B1-B13 (all)
Isolation, electrostatic discharge, filtering	3.3.3.2.1	4.4.2.4.2.1	X			B1/2/8/9
Cell protective covering	3.3.4.1	Vendor Cert	X	X		B1-B13 (all)

TABLE VII. Inspection requirements - Continued.

Inspection	Requirement paragraph	Test method paragraph	Qual	Conformance		Sample assignment[1]
				IPI	PPI	
Cell leakage	3.3.4.2	Vendor Cert	X	X		B1-B13 (all)
Battery case	3.3.5.1	4.4.2.5.1	X			C1-5 or Vendor Cert
Battery accessories	3.3.5.2	4.4.2.1	X	X		B1-B13 (all)
Overpressure relief device	3.3.5.2.1	4.4.2.5.2	X	X		B1-B13 (all)
Air pressure equalization port	3.3.5.2.2	4.4.2.5.3	X	X		B1-B13 (all)
Heater(s)	3.3.5.2.3	4.4.2.5.4	X			B6/7/11
Handles	3.3.5.2.4	4.4.2.5.5	X	X		WC1
Battle override mode	3.3.6	Vendor Cert, 4.4.2.6	X			B1-B13 (all)
Battery color	3.4.1	Vendor Cert, 4.4.2.1	X	X		B1-B13 (all)
Marking, general	3.4.2	4.4	X			B1-B13 (all)
Marking print and color	3.4.2.1	4.4.2.1	X			B1-B13 (all)
Permanence and durability	3.4.2.2	4.4.2.1, 4.4.2.2	X			B1-B13 (all)
Battery identification marking	3.4.3.1	4.4.2.1	X			B1-B13 (all)
Date of battery manufacture and lot code	3.4.3.1.1	4.4.2.1	X			B1-B13 (all)
Item unique identification (IUID)	3.4.3.2	4.4.2.1	X			B1-B13 (all)
Maintenance advisory tag	3.4.3.3	4.4.2.1	X			B1-B13 (all)
Instruction and notes	3.4.4	4.4.2.1	X			B1-B13 (all)
General warning marking	3.4.5.1	4.4.2.1	X			B1-B13 (all)
Hazard severity label	3.4.5.2	4.4.2.1	X			B1-B13 (all)
Dielectric strength and insulation resistance	3.5.1	4.4.4	X			B1/2
Operating and storage temperature range	3.5.2	4.4.5	X	X		B6/7
Battery voltage	3.5.3	Vendor Cert	X	X		B1-B13 (all)
Full charge capacity	3.5.4	4.4.6.1	X	X	X	B1/2/3/4/5/8 /9/10/12/13
Cranking amps	3.5.5	4.4.6.2	X	X	X	B6/7/11
Deep cycle life	3.5.6	4.4.6.3	X	X		B1/2
High temperature deep cycle life	3.5.7	4.4.6.4	X	X		B3/4
Retention of charge	3.5.8	4.4.6.5	X	X		B10/11
Battery storage life	3.5.9	4.4.7	X	X		B5
Battery service life	3.5.10	4.4.8	X	X		B1-B13 (all)

TABLE VII. Inspection requirements - Continued.

Inspection	Requirement paragraph	Test method paragraph	Qual	Conformance		Sample assignment[1]
				IPI	PPI	
Charging	3.5.11	4.4.9	X	X	X	B1-B13 (all)
Jump start power export	3.5.12	4.4.10	X	X		B1-B13 (all)
Jump start power import	3.5.13	4.4.11	X	X		B1-B13 (all)
Battery management system (BMS)	3.6.1	4.5.1	X			B1-B13 (all)
BMS power	3.6.2	4.5.2	X	X		B1-B13 (all)
BMS features	3.6.3	4.5.3				B1-B13 (all)
Monitoring	3.6.3.1	4.5.3.1	X	X		B1-B13 (all)
Equalization	3.6.3.2	4.5.3.2	X	X		B1-B13 (all)
Safety protections	3.6.3.3	4.5.3.3	X	X	X	B6/7/8/9/10/ 11/12
Enable/disable automated heaters	3.6.3.4	4.5.3.4	X			B1/2
Contactor(s)	3.6.3.5	4.5.3.5	X			B1/2
Communication interface	3.6.4	4.5.4	X	X		B1-B13 (all)
Configuration pins	3.6.4.1	4.5.4.1	X			B1/2
Position identity	3.6.4.2	4.5.4.2	X			B1/2
Dual CAN interface	3.6.4.3	4.5.4.3	X			B1/2
Baud rate	3.6.4.4	4.5.4.4	X			B1/2
NAME	3.6.4.5	4.5.4.5	X			B1/2
Preferred source address	3.6.4.6	4.5.4.6	X			B1/2
Arbitrary address capable	3.6.4.6.1	4.5.4.6.1	X			B1/2
Service configurable source address	3.6.4.6.2	4.5.4.6.2	X			B1/2
Termination resistance	3.6.4.7	4.5.4.7	X			B1/2
Firmware update over CAN bus	3.6.4.8	4.5.4.8	X			B1/2
Monitoring performance characteristics	3.6.5	4.5.5				
Calculated parameters	3.6.5.1	4.5.5.1				
State of charge (%)	3.6.5.1.1	4.5.5.1.1	X			B1-B13 (all)
State of health (%)	3.6.5.1.2	4.5.5.1.2	X			B1-B13 (all)
Capacity estimation	3.6.5.1.3	4.5.5.1.3	X			B1-B13 (all)
Time remaining (at present rate of discharge)	3.6.5.1.4	4.5.5.1.4	X			B1-B13 (all)
Bus voltage request (for charging)	3.6.5.1.5	4.5.5.1.5	X			B1-B13 (all)
Open circuit voltage	3.6.5.1.6	4.5.5.1.6	X			B1-B13 (all)
Battery power capability prediction	3.6.5.1.7	4.5.5.1.7	X			B6/7/11

TABLE VII. Inspection requirements - Continued.

Inspection	Requirement paragraph	Test method paragraph	Qual	Conformance		Sample assignment[1]
				IPI	PPI	
Measured parameters	3.6.5.2	4.5.5.2				
Battery voltage (V)	3.6.5.2.1	4.5.5.2.1	X			B1-B13 (all)
Battery current (A)	3.6.5.2.2	4.5.5.2.2	X			B1-B13 (all)
Internal battery temperature (°C)	3.6.5.2.3	4.5.5.2.3	X			B1-B13 (all)
Celsius and Fahrenheit support	3.6.5.2.4	4.5.5.2.4	X			B1-B13 (all)
Manufacturer specific parameters	3.6.5.3	4.5.5.3	X			B1-B13 (all)
Cell voltages	3.6.5.3.1	4.5.5.3.1	X			B1-B13 (all)
Equalization	3.6.5.3.2	4.5.5.3.2	X			B1-B13 (all)
Built-in test (BIT) results	3.6.5.3.3	4.5.5.3.3	X			B1-B13 (all)
Celsius support	3.6.5.3.4	4.5.5.3.4	X			B1-B13 (all)
Battery states	3.6.6	4.5.6	X			B1-B13 (all)
Dormant (off) State	3.6.6.1	4.5.6.1	X			B1-B13 (all)
Initialize State	3.6.6.2	4.5.6.2	X			B1-B13 (all)
Operational State	3.6.6.3	4.5.6.3	X			B1-B13 (all)
Maintenance State	3.6.6.4	4.5.6.4	X			B1-B13 (all)
Protected State	3.6.6.5	4.5.6.5	X			B1-B13 (all)
Built-in tests	3.6.7	4.5.7	X			B1-B13 (all)
Power-up BIT	3.6.7.1	4.5.7.1	X			B1-B13 (all)
Continuous BIT	3.6.7.2	4.5.7.2	X			B1-B13 (all)
BIT diagnostics probability	3.6.7.3	4.5.7.3	X	X		B1-B13 (all)
Long term fault data storage (non-volatile)	3.6.8	4.5.8	X			B1-B13 (all)
Short term fault data storage (volatile)	3.6.9	4.5.9	X			B1-B13 (all)
Surges, spikes, and disturbances	3.7	4.6	X	X		B6/7
Voltage surges	3.7.1	4.6.1	X	X		B6/7
Voltage spikes	3.7.2	4.6.2	X	X		B6/7
Starting disturbance	3.7.3	4.6.3	X	X		B6/7
Starting current	3.7.3.1	4.6.4	X	X		B1-B13 (all)
Steady state surges	3.7.4	4.6.5	X	X		B6/7
Steady state spikes	3.7.5	4.6.6	X	X		B6/7
Altitude	3.8.1.1	4.7.1.1	X	X		B6/10
Rapid decompression	3.8.1.2	4.7.1.2	X	X		B7/10
Attitude	3.8.2	4.7.2	X	X		B10/11
Thermal shock	3.8.3	4.7.3	X	X		B6/7
Mechanical shock	3.8.4	4.7.4	X	X		B8/12
Vibration	3.8.5	4.7.5	X	X		B9/13

TABLE VII. Inspection requirements - Continued.

Inspection	Requirement paragraph	Test method paragraph	Qual	Conformance		Sample assignment[1]
				IPI	PPI	
Immersion	3.8.6	4.7.6	X	X		B8/9
Humidity	3.8.7	4.7.7	X	X		B12/13
Blowing dust	3.8.8	4.7.8	X	X		B12/13
Salt atmosphere	3.8.9	4.7.9	X	X		B12
Fluid susceptibility	3.8.10	4.7.10	X	X		B13
Explosive atmosphere	3.8.11	4.7.11	X	X		B12/13
Electromagnetic compatibility/interference	3.9	4.8	X	X		B8/9
Electrostatic discharge	3.10	4.9	X	X		B8/9
Cell safety abuse test	3.11.1.1	Vendor Cert (4.10.1.1)	X	X		B1-B13 (all)
Cell overcharge	3.11.1.1.1	Vendor Cert (4.10.1.1.1)	X	X		B1-B13 (all)
Cell short circuit	3.11.1.1.2	Vendor Cert (4.10.1.1.2)	X	X		B1-B13 (all)
Cell over discharge	3.11.1.1.3	Vendor Cert (4.10.1.1.3)	X	X		B1-B13 (all)
Cell penetration	3.11.1.1.4	Vendor Cert (4.10.1.1.4)	X	X		B1-B13 (all)
Cell crush	3.11.1.1.5	Vendor Cert (4.10.1.1.5)	X	X		B1-B13 (all)
Cell leakage	3.11.1.2	Vendor Cert (4.10.1.2)	X	X		B1-B13 (all)
Battery over-current protection	3.11.2.1	4.10.2.1	X	X		B8/9
Overcharge abuse[2]	3.11.2.2.1	4.11	X			N1
Overcharge protection	3.11.2.2.2	4.10.2.2	X	X		B8/9
Battery over-discharge protection	3.11.2.3	4.10.2.3	X	X		B8/9
Battery over temperature protection	3.11.2.4	4.10.2.4	X	X		B6/7
Battery low temperature charge protection	3.11.2.5	4.10.2.5	X	X		B1-B13 (all)
Battery impact resistance (non-metallic battery case only)	3.11.2.6	4.10.2.6	X			C6-9
Battery abuse	3.11.2.7	4.10.2.7				
Battery crush[2]	3.11.2.7.1	4.10.2.7.1	X	X		B6
Battery nail penetration[2]	3.11.2.7.2	4.10.2.7.2.1	X	X		B7

TABLE VII. Inspection requirements - Continued.

Inspection	Requirement paragraph	Test method paragraph	Qual	Conformance		Sample assignment[1]
				IPI	PPI	
Battery projectile penetration[2]	3.11.2.7.2	4.10.2.7.2.2	X	X		B8/9
Battery drop low height	3.11.2.7.3	4.10.2.7.3	X	X		B10
Battery drop high height[2]	3.11.2.7.4	4.10.2.7.4	X	X		B10/11
Lithium battery safety program (U.S. NAVY)[2]	3.12	4.11	X			N1-15
Charger compatibility	3.13	4.12	X	X		B10
Workmanship	3.14	4.13	X	X	X	B1-B13 (all)
Paint, protective finishes, and coatings	3.15.1	4.14.1	X	X		B1-B13 (all)
Corrosion resistance	3.15.2	4.14.2	X	X		B1-B13 (all)
Restricted materials	3.15.3	4.14.3	X	X		B1-B13 (all)
Electronic assemblies	3.16	4.15	X	X		B1-B13 (all)
Hazardous materials	3.17	4.16	X	X		B1-B13 (all)
Chemical, biological, radiological and nuclear (CBRN)	3.18	4.17	X	X		B1-B13 (all)
Defects	3.19	4.18	X	X	X	B1-B13 (all)

NOTES:
1. B: battery sample, N: Navy battery sample, C: case sample, WC: weighted case sample.
2. This is a destructive test and shall be conducted after all other inspections have been completed for the listed assigned battery sample.

4.2 Test equipment and facilities. The tests in this specification shall be conducted in a test facility having a calibration system which complies with NCSL Z540.3, ISO 10012, or equivalent system as approved by the qualifying activity.

4.2.1 Voltage and current indicating equipment. All voltage and current indicating equipment shall be accurate within one percent of the full scale reading.

4.2.2 Voltage and current tolerances. During the charging and discharging of batteries the current and voltage shall be maintained within one percent of the value specified at all times, unless otherwise specified. Unless otherwise specified all discharges shall be continuous.

4.2.3 Resistance tolerances. Resistance shall be accurate within ±0.5 percent for all tests.

4.2.4 Time of discharge. The timing of discharges lasting not longer than one minute shall be maintained to within ±5 percent. All other discharge times shall be accurate within ±1 percent.

4.3 Inspection conditions. Unless otherwise specified, all examinations and tests shall be performed under ambient humidity and ambient atmospheric pressure conditions at normal temperature (see 4.3.1.1).

4.3.1 Temperature conditions.

4.3.1.1 Normal conditions. Normal ambient temperature for tests shall be 22±5 °C. When normal conditions are specified, tests shall be conducted and measurements taken at ambient atmospheric pressure and relative humidity, with a maximum rest time of 1 hour between charge and discharge, except for cycle life tests.

4.3.1.2 Transitioning between temperatures. When transitioning between temperatures that have a difference greater than 10 °C, the batteries shall remain at the new condition and shall stabilize for not less than 12 hours unless otherwise specified. When transitioning between temperatures that have a difference less than or equal to 10 °C, the batteries shall remain at the new condition and shall stabilize for not less than 6 hours unless otherwise specified.

4.3.2 Mounting. Batteries shall not be altered for mounting purposes to perform the vibration and mechanical shock tests. Where brackets exist, for the sole purpose of mounting the battery, these brackets shall be used. Vibration isolators shall not be used.

4.4 Inspection and test methods.

4.4.1 Engineering analysis. The purpose of engineering analysis is to provide objective evidence as to the ability of the battery to meet performance characteristics where component level testing or inspection is either not required, due to previous experience or testing, or is not feasible due to unrealistic inspection conditions. Analysis may consist of evaluation of data accumulated from inspection, demonstration, test and product design requirements simulation, modeling, interpretation and/or parts similarity. Analysis may include engineering calculations if applicable. The resultant analysis of this data should be organized to provide evidence that a particular requirement has been met.

4.4.2 Visual and mechanical inspections and tests. Reworking of samples shall be permitted as specified in the contract or by approval of the qualification authority (see 3.19).

4.4.2.1 Incoming visual and mechanical inspection. Samples shall be examined to verify that the basic materials, component materials and parts, design and construction, marking and workmanship are in accordance with the requirements of 3.19.

4.4.2.2 Post-test visual and mechanical inspection. Except where noted, samples shall be examined after testing in section 4 to verify conformance to 3.19.

4.4.2.3 Dimension and weight measurement. To determine conformance to 3.3.2, batteries shall be measured and weighed. All measurements shall include any coating and labels.

4.4.2.4 Electrical interface.

4.4.2.4.1 Terminal posts and threaded sockets. Terminal posts and threaded sockets shall be visually inspected to determine conformance to 3.3.3.1. The electrically conductive pad shall be measured to ensure the pad is at least level 2 mm above the top surface of the battery, and not more than 3 mm above the surface. The electrically insulative area around the electrically conductive pad shall be measured to ensure it is not more than 1 mm above the top surface of the battery. Additionally, an increasing torque up to 28.25 Newton-meters (N-m) shall be applied in a direction perpendicular to the axis of the terminal posts and parallel to the top of the battery by a torque indicating device, through a nondestructive battery terminal fitting or other clamping device on the conical section of the terminal posts. This test shall be repeated using a torque wrench on the hex nut portion of the terminal posts. The torque shall be performed in a clockwise direction. To test battery clamp slippage, battery clamps shall be attached to each terminal post with the rated torque. The battery shall be suspended by the battery clamps for one hour. The clamps shall not completely slip off the terminal posts during the one hour. The battery clamps for the terminals to be used in the slip testing shall conform to part number AA-52425-1 (NSN 5940-00-549-6581) for the positive and AA-52425-2 (NSN 5940-00-549-6583) for the negative. After the torque and battery clamp slippage test has been performed, the same battery shall undergo the immersion test in accordance with 4.7.6.

4.4.2.4.2 Communication interface. Engineering analysis shall be performed on the communication interface to determine conformance to 3.3.3.2.

4.4.2.4.2.1 Isolation, ESD, filtering. Conformance to 3.3.3.2.1 shall be verified during performance of 4.4.4, 4.8, and 4.9.

4.4.2.5 Battery case and accessories.

4.4.2.5.1 Battery case. To determine conformance to 3.3.5.1, when a non-metallic material is used for the battery case, the Horizontal Burning Test specified in UL 94 shall be performed on five sample pieces of case material. Expose samples to a flame for not less than 30 seconds.

4.4.2.5.2 Overpressure relief device. To determine conformance to 3.3.5.2.1, vendor certification is required.

4.4.2.5.3 Air pressure equalization port. To determine conformance to 3.3.5.2.2, vendor certificaiton is required.

4.4.2.5.4 Heater(s). Conformance to 3.3.5.2.3 shall be verified during performance of 4.4.6.2 b.

4.4.2.5.5 Handles. To determine conformance to 3.3.5.2.4 a weighted battery case (with a weight equal to the max weight specified in table I shall be placed in an environmental chamber with temperature of 88±3 °C for 60 minutes, allowed to return to normal conditions, and again heated at 88±3 °C for 60 minutes. The weighted battery case shall then be removed from the environmental chamber and immediately placed in a test fixture (see figure 11). The case shall be initially set on the removable support, and the angles and initial tautness of the handles shall be set with the support in place. The ballast weight, equal to the max weight specified in table I, shall be placed on top of the weighted case. The support shall then be slowly removed and the weighted case and ballast weight be allowed to hang freely by the handles for 60 seconds. The weighted case shall then be removed and the handles and bond shall be examined for conformance to 3.3.5.2.4. The test shall be repeated at -54±3 °C.

4.4.2.6 Battle override mode. Vendor certification that battery is compliant with 3.3.6 is required.

4.4.3 Potting/sealing compounds, flow and shrinkage. The following test shall be performed on any insulating compounds that may be used in battery construction. Place compound in a container, approximately 76.2 mm wide by 152.4 mm long by 19.1 mm high, to within 12.7 mm of the top and allow curing in accordance with the manufacturer's recommended procedures. Place the container in an environmental chamber in an inverted position and raise the temperature to 93±3 °C. Keep the container inverted at these conditions for not less than 24 hours. The test sample shall meet the requirements of 3.2.4.1. Place the container in an environmental chamber in an inverted position and lower the temperature to -54±3 °C; hold these conditions for not less than eight hours. The test sample shall meet the requirements of 3.2.4.1.1.

4.4.4 Dielectric strength and insulation resistance. To determine conformance to 3.5.1, the following tests shall be performed.

4.4.4.1 Dielectric strength. To verify conformance to 3.5.1, apply a direct-current potential of 500±25 volts in accordance with MIL-STD-202-301 for 60 to 65 seconds between the battery electrical contacts listed below.

a. Battery positive terminal and battery case.

b. Battery negative terminal and battery case.

c. All communication interface contacts, except power and power return, and positive terminal.

d. All communication interface contacts, except power and power return, and negative terminal.

e. All communication interface contacts and battery case.

Note. Test each battery case in not less than three locations and on all surfaces with a case seam other than that on which the battery terminals are located. For plastic case batteries, measure the insulation resistance of batteries by the use of a copper plate making physical contact with the case. The plate shall exceed the dimensions of the surface to be tested. Place the battery to be tested on the plate so that the plate is visible outside all edges of the surface under test.

4.4.4.2 Insulation resistance. Apply an alternating current potential of 500±25 volts for 60 to 65 seconds to the components listed in 4.4.4.1. Measure the insulation resistance of the components in accordance with test condition B of MIL-STD-202-302, for 60 seconds. Batteries shall meet the requirements of 3.5.1.

4.4.5 Operating and storage temperature range. To determine conformance to 3.5.2, charge battery in accordance with 4.4.9 and place it in a thermal chamber at -51±3 °C for 24 hours, then change thermal chamber temperature to -46±3 °C and soak the battery for 12 hours. Verify battery is operational by performing a discharge at C/10 for one hour. Battery voltage shall remain above the minimum voltage specified in 3.5.3 for the entire hour. Repeat test on all samples at 85±3 °C for the 24 hour soak and 71±3 °C for the 12 hour soak.

4.4.6 Performance tests.

4.4.6.1 Full charge capacity. To determine conformance to 3.5.4, the battery full charge capacity rating (ampere-hours) shall be determined as follows:

a. Discharge battery at 1C rate until the terminal cutoff voltage defined by the battery manufacturer is reached (this voltage must be compliant with 3.5.3).

b. Charge battery in accordance with 4.4.9 before each discharge.

c. Place battery at normal conditions for at least 6 hours.

d. Discharge battery at 1C rate until the terminal cutoff voltage defined by the battery manufacturer is reached (this voltage must be compliant with 3.5.3). Record the discharge time, and calculate the capacity in ampere hour.

e. Two additional attempts are permitted of a. through c. to meet full charge capacity requirements.

f. The capacity obtained from each battery subjected to steps c. or d. shall represent the full charge capacity. Exception: If the full charge capacity is met in step c. or d., extra steps are not required.

4.4.6.2 Cranking amps. Each battery listed for cranking amps testing in table VII shall undergo all steps listed in sections a and b below.

a. No prior heating. Battery heater(s) shall be deactivated for test section a. To determine conformance to 3.5.5, the test for cranking amps at -40, -32, -18, and 55 °C shall be performed as follows:

(1) Charge battery in accordance with 4.4.9.
(2) Place battery in an environmental chamber at a temperature of -40±3 °C. Verify heater is inactive.

(3) The battery shall remain in the environmental chamber at -40±3 °C for at least 12 hours. Remove the battery from the environmental chamber, and within 5 minutes, discharge the battery at the cranking amps (no pre-heating) rate and time as specified in table I for that temperature. Monitor voltage of battery during test to verify compliance to voltage specified in table I.
(4) Measure and record battery voltage at end of test (see 3.5.3).
(5) If battery voltage during or at the end of test fails to meet the requirements of 3.5.5, it shall be retested as specified in steps (1) through (4). Failure of a battery to pass this second cycle shall be considered as failure to meet the specified requirements.
(6) Allow battery to rest for 5 minutes at normal conditions. Within one minute before the end of the rest, record the reported 30 second battery power prediction capability value. Immediately after the 5 minute rest, discharge the battery at the rate recorded for 30 seconds or until voltage drops below the battery's terminal cutoff voltage specified in 4.4.6.1 d. If the voltage drops below the battery's terminal cutoff voltage specified in 4.4.6.1 d before 30 seconds, this constitutes as a failure of this test.
(7) Allow battery to rest for 5 minutes at normal conditions. Within one minute before the end of the rest record the reported 10 second battery power prediction capability value. Immediately after the 5 minute rest, discharge the battery at the rate recorded for 10 seconds or until voltage drops below the battery's terminal cutoff voltage specified in 4.4.6.1 d. If the voltage drops below the battery's terminal cutoff voltage specified in 4.4.6.1 d before 10 seconds, this constitutes as a failure of this test.
(8) Test in accordance with 4.4.6.1.
(9) Repeat steps (1) through (8) except temperature shall be -32±3 °C.
(10) Repeat steps (1) through (8) except temperature shall be -18±3 °C.
(11) Repeat steps (1) through (8) except temperature shall be 55±3 °C.

b. With prior heating. To determine conformance to 3.5.5, the test for cranking amps at -18 and -48 °C shall be performed as follows:

(1) Charge battery in accordance with 4.4.9.
(2) Place battery in an environmental chamber at a temperature of -48±3 °C.
(3) The battery shall remain in the environmental chamber at -48±3 °C for at least 12 hours. Initiate heating and allow heater to operate for 30 minutes. Ensure heater has been turned off. Remove the battery from the environmental chamber within 1 minute of heater termination. Within 5 minutes of removal from environmental chamber, discharge the battery at the cranking amps (30 min pre-heating) rate and time as specified in table I. Monitor voltage of battery during test to verify compliance to voltage specified in table I.
(4) Measure and record battery voltage at end of test (see 3.5.3).
(5) If battery fails the test, it shall be retested. The retested battery shall be charged, and shall be retested as specified in (1) through (4). Failure of a

battery to pass this second cycle shall be considered as failure to meet the specified requirements.

(6) Test in accordance with 4.4.6.1.

(7) Repeat steps (1) through (6) except temperature shall be -18±3 °C, and the heater shall run for 10 minutes. The rate and time shall be as specified in table I under cranking amps (10 min pre-heating).

4.4.6.3 Deep cycle life. To determine conformance to 3.5.6, perform the following test procedure:

a. Perform full charge capacity test in accordance with 4.4.6.1. Record the full charge capacity from 4.4.6.1 d. This full charge capacity shall be used to establish the baseline capacity for the 80 percent requirement of 3.5.6.

b. Charge battery in accordance with 4.4.9.

c. Place battery in an environmental chamber and stabilize at a temperature of 38±3 °C.

d. Discharge at the 1C rate to the battery's terminal cutoff voltage specified in 4.4.6.1 d.

e. Allow the battery to rest five minutes.

f. Charge battery in accordance with 4.4.9, except perform at a temperature of 38±3 °C.

g. Allow the battery to rest five minutes.

h. Repeat steps c through f for a total of 1000 cycles.

i. Remove from the environmental chamber and stabilize at normal conditions.

j. Perform full charge capacity test in accordance with 4.4.6.1. Record the full charge capacity from 4.4.6.1 d and compare to baseline capacity from step a.

4.4.6.4 High temperature deep cycle life. To determine conformance to 3.5.7, perform the following test procedure:

a. Perform full charge capacity test in accordance with 4.4.6.1. Record the full charge capacity from 4.4.6.1 d. This full charge capacity shall be used to establish the baseline capacity for the 80 percent requirement of 3.5.7.

b. Charge the battery in accordance with 4.4.9.

c. Place battery in an environmental chamber and stabilize at a temperature of 50±3 °C.

d. Discharge at the 1C rate to the battery's terminal cutoff voltage specified in 4.4.6.1 d.

e. Allow the battery to rest five minutes.

f. Charge battery in accordance with 4.4.9, except perform at a temperature of 50±3 °C.

g. Allow the battery to rest five minutes.

h. Repeat steps c through f for a total of 500 cycles.

i. Remove from the environmental chamber and stabilize at normal conditions.

j. Perform full charge capacity test in accordance with 4.4.6.1. Record the full charge capacity from 4.4.6.1 d and compare to baseline capacity from step a.

4.4.6.5 Retention of charge. Each battery listed for retention of charge testing in table VII shall undergo all steps listed in section below. To determine conformance to 3.5.8, the retention of charge test shall be performed as follows:

a. Charge battery as specified in 4.4.9.

b. Place the battery in an environmental chamber at 40±3 °C for 90 calendar days. Ensure the battery is in the Operational State with master power switch “Off” (see 3.6.6.3).

c. After 90 calendar days, allow battery to stabilize at normal conditions for at least 12 hours but no more than 48 hours.

d. NOTE: DO NOT RECHARGE BATTERY PRIOR TO NEXT STEP.

e. Perform two successive cranks according to the pulse load rating in table I at normal conditions. There shall be a five minute rest between each of the two cranks, with no recharge in between cranks.

f. Repeat the test, steps a through e at -40±3 °C.

4.4.7 Battery storage life. To determine conformance to 3.5.9, perform the following test procedure:

a. Charge the battery in accordance with 4.4.9.

b. Store the battery for not less than 24 months in a controlled temperature environment at 22±5 °C.

c. Without first recharging the battery, perform the full charge capacity test in 4.4.6.1 steps c through f.

d. Examine the battery for the requirements of 4.4.2.2.

4.4.8 Battery service life. To determine conformance to 3.5.10, vendor certification is required.

4.4.9 Charging. To determine conformance to 3.5.11, the battery temperature is to be stabilized at 22±5 °C before charging commences. Batteries shall be charged using a constant voltage of 28.5±0.25 V. The charge is to be terminated after current tapers to C/20 rate, or the battery contactor opens. The charging supply shall be capable of providing the continuous current charge rating as specified in table I. If testing on any battery is temporarily stopped for a period of 72 hours or more, the battery shall be given a charge according to this section. A test battery shall not be stored for more than 1 hour after a discharge without beginning recharge procedures. When batteries are not on test they shall be placed in the Dormant State.

4.4.10 Jump start power export. Vendor certification that battery is compliant with 3.5.12 is required.

4.4.11 Jump start power import. Vendor certification that battery is compliant with 3.5.13 is required.

4.5 Battery management system requirements.

4.5.1 Battery management system. To determine conformance to 3.6.1 an engineering analysis (see 4.4.1) shall be conducted.

4.5.2 BMS power. Vendor certification that battery is compliant with 3.6.2 is required.

4.5.3 BMS features.

4.5.3.1 Monitoring. Conformance to 3.6.3.1 shall be determined through system testing and engineering analysis maintained and documented throughout the battery lifecycle.

4.5.3.2 Equalization. Vendor certification that battery is compliant with 3.6.3.2 is required.

4.5.3.3 Safety protections. The conformance to 3.6.3.3 shall be determined by successful protection of the battery during tests in 4.10.2.

4.5.3.4 Enable/disable automated heaters. To determine conformance to 3.6.3.4, the battery shall be placed in the Maintenance State and sent the battery configuration message with parameter "Automated Heater Function" value set to "Disable Automated Heater Function." The battery shall be monitored for positive acknowledgment over the CAN communication bus. The battery shall be sent the configuration message with parameter "Automated Heater Function" value set to "Enable Automated Heater Function." The battery shall be monitored for positive acknowledgment over the CAN communication bus.

4.5.3.5 Contactor(s). To determine conformance to 3.6.3.5, the battery shall be placed in the Operational State and sent the battery configuration message with parameter "Command Contactor(s)" value set to "Open Contactor(s)." The battery shall be monitored for positive acknowledgment and contactor(s) status over the CAN communication bus. The voltage at the terminals of the battery shall be monitored to verify that electrical power is not available. The battery shall be sent the configuration message with parameter "Command Contactor(s)" value set to "Automated Contactor Operation." The battery shall be monitored for positive acknowledgment and contactor(s) status over the CAN communication bus. The voltage at the terminals shall be monitored to verify availability of electrical power. The battery shall be sent the configuration message with parameter "Command Contactor(s)" value set to "Force Contactor(s) Closed." The battery shall be monitored for negative acknowledgment and no change to contactor(s) status over the CAN communication bus. The battery shall be placed in the Maintenance State, and sent the battery configuration message with parameter "Command Contactor(s)" value set to "Force Contactor(s) Closed." The battery shall be monitored for positive acknowledgment and contactor(s) status over the CAN communication bus. The voltage at the terminals shall be monitored to verify availability of electrical power. Vendor certification required for switching a minimum of 100,000 times.

4.5.4 Communication interface. Vendor certification that battery is compliant with SAE J1939 and ISO 11898 is required (see 3.6.4).

4.5.4.1 Configuration pins. To determine conformance to 3.6.4.1, the battery shall be sent a request for "Configuration State Message 1." Response message shall be compared to the state of the configuration pins attached to the communication interface.

4.5.4.2 Position identity. To determine conformance to 3.6.4.2, the battery shall be sent a request for "Configuration State Message 1." Response message shall be compared to the state of the configuration pins attached to the communication interface. The battery shall be sent a RQST message to obtain the SAE J1939 NAME. The function instance of the NAME shall be compared to the position identity.

4.5.4.3 Dual CAN interfaces. To determine conformance to 3.6.4.3, communication of the battery on the CAN interfaces shall be monitored in the Operational State with CAN A configured as the primary interface, and repeated with CAN B configured as the primary interface.

4.5.4.4 Baud rate. To determine conformance to 3.6.4.4, the battery shall be configured to baud rates: 250 Kbps, 500 Kbps, and 1 Mbps. The battery shall be monitored in the Operational State to verify the baud rate over the communication interface CAN bus.

4.5.4.5 NAME. To determine conformance to 3.6.4.5, the battery shall be sent a RQST message to obtain the SAE J1939 NAME, and response message shall be monitored to verify the NAME fields. The battery shall then be placed in the Maintenance State, and the NM Message shall be used to modify each of the NAME fields to a value other than the default. A RQST message for the SAE J1939 NAME shall be sent to the battery, and the response message shall be monitored to verify the NAME fields have been updated.

4.5.4.6 Preferred source address. To determine conformance to 3.6.4.6, the battery shall be have position identity pins set to a position identities between 0 and 15 on subsequent trials. The battery shall be monitored in Operational State to verify that the correct preferred source address is used based on the position identity.

4.5.4.6.1 Arbitrary address capable. Vendor certification that the battery supports SAE J1939 arbitrary address capability shall be required. To determine conformance to 3.6.4.6.1, the battery shall be placed in the Maintenance State, and the arbitrary address capability shall be set to the desired state using the NM message according to the procedures found in SAE J1939-81. The battery NAME arbitrary address capable field shall be verified using the Request Current NAME method in SAE J1939-81 or using the RQST for Address Claimed (AC) message.

4.5.4.6.2 Service configurable source address. To determine conformance to 3.6.4.6.2, the battery shall be placed in the Maintenance State, and given a new preferred source address using the CA message according to SAE J1939-81. The battery source address shall be verified using the Request NAME Address Claim method in SAE J1939-81 or using the Request for Address Claim message.

4.5.4.7 Termination resistance. To determine conformance to 3.6.4.7, the resistance between CAN high and low pins for CAN A and CAN B interfaces shall be measured using a calibrated resistance meter.

4.5.4.8 Firmware update over CAN bus. To determine conformance with 3.6.4.8, the battery shall be configured with baud rate of 250 Kbps and placed in the Maintenance State to perform a firmware update. The non-volatile memory in the battery shall be loaded with data containing a known unique configuration identifier different from the identifier initially resident in the memory. Correct loading shall be demonstrated by verifying checksums and the configuration identifier stored in memory after reprogramming. It shall be verified that this reprogramming operation is complete within 15 minutes. Test shall be repeated at 500 Kbps and 1 Mbps.

4.5.5 Monitoring performance characteristics.

4.5.5.1 Calculated parameters. The battery shall be monitored in Operational State to verify correct transmission rates as configured for messages containing calculated parameters (see 3.6.5.1). Set battery transmission rate of messages containing calculated parameters to 15 seconds. Verify correct transmission rate. Repeat with battery transmission rate set to on request only. Repeat with battery transmission rate for Battery Power Capability Prediction message set to one second and then repeat with five seconds.

4.5.5.1.1 State of charge (percent). The battery shall be monitored in the Operational State to verify that the state of charge is communicated over the CAN bus within the accuracy tolerances listed in table IV of the actual battery state of charge during performance tests (see 4.4.6 and 3.6.5.1).

4.5.5.1.2 State of health (percent). The battery shall be monitored in the Operational State to verify that the state of health is communicated over the CAN bus within the accuracy tolerances listed in table IV of the actual battery state of health during performance tests (see 4.4.6 and 3.6.5.1).

4.5.5.1.3 Capacity estimation. The battery shall be monitored in the Operational State to verify that the capacity is communicated over the CAN bus during performance tests (see 4.4.6 and 3.6.5.1).

4.5.5.1.4 Time remaining (at present rate of discharge). The battery shall be monitored in the Operational State to verify that the time remaining is communicated over the CAN bus during performance tests (see 4.4.6 and 3.6.5.1).

4.5.5.1.5 Bus voltage request (for charging). The battery shall be monitored in the Operational State to verify that the bus voltage request is communicated during battery charge over the CAN bus during performance tests (see 4.4.6 and 3.6.5.1).

4.5.5.1.6 Open circuit voltage. The battery shall be monitored in the Operational State to verify that the open circuit voltage is communicated over the CAN bus during performance tests (see 4.4.6 and 3.6.5.1).

4.5.5.1.7 Battery power capability prediction. Conformance to 3.6.5.1.7 shall be verified during the cranking amps test (see 4.4.6.2).

4.5.5.2 Measured parameters. The battery shall have the transmission rate of messages containing measured parameters configured to 1, 5, and 15 seconds, and on request only when battery is in Maintenance State. The battery shall be monitored in Operational State to verify correct transmission rates as configured for messages containing measured parameters (see 3.6.5.2).

4.5.5.2.1 Battery voltage (V). The battery shall be monitored in the Operational State to verify that the battery voltage within the accuracy tolerances listed in table IV is communicated over the CAN bus and shall be compared to a secondary calibrated voltmeter during performance tests (see 4.4.6 and 3.6.5.2.1).

4.5.5.2.2 Battery current (A). The battery shall be monitored in the Operational State to verify that the battery current within the accuracy tolerances listed in table IV is communicated over the CAN bus and shall be compared to a secondary calibrated ammeter during performance tests (see 4.4.6 and 3.6.5.2.2)

4.5.5.2.3 Internal battery temperature (°C). Engineering analysis of temperature sensing method and hardware shall be used to determine conformance to 3.6.5.2.3

4.5.5.2.4 Celsius and Fahrenheit support. The battery shall be monitored in the Operational State to verify that the battery internal temperature within the accuracy tolerances listed in table IV is communicated over the CAN bus. Temperature reading in Fahrenheit shall be converted and compared to the reading in Celsius to verify equivalence (see 3.6.5.2.4).

4.5.5.3 Manufacturer specific parameters. The battery shall have the transmission rate of messages containing manufacturer specific parameters configured to 1, 5, and 15 seconds, and on request only when battery is in Maintenance State. The battery shall be monitored in Operational State to verify correct transmission rates as configured for messages containing manufacturer specific parameters (see 3.6.5.3).

4.5.5.3.1 Cell voltages. The battery shall be monitored in the Operational State to verify that cell voltages are reported on the CAN bus to determine conformance to 3.6.5.3.1. CAN messages containing cell voltages shall be tested in accordance with 4.5.5.3.

4.5.5.3.2 Equalization. The battery shall be monitored in the Operational State to verify that equalization information is reported on the CAN bus to determine conformance to 3.6.5.3.2. CAN messages containing equalization information shall be tested in accordance with 4.5.5.3.

4.5.5.3.3 BIT results. The battery shall be monitored in the Operational State to verify that BIT results are reported on the CAN bus to determine conformance to 3.6.5.3.3. CAN messages containing BIT results shall be tested in accordance with 4.5.5.3. Communication of faults and failures in the form of DTCs shall be verified in tests in 4.10.2 and engineering analysis maintained and documented throughout the battery lifecycle.

4.5.5.3.4 Celsius support. Testing shall be conducted in accordance with 4.5.5.3 to determine conformance to 3.6.5.3.4. Messages containing manufacturer specific parameters that have temperature data shall be analyzed and verified that the temperatures are reported in Celsius.

4.5.6 Battery states.

4.5.6.1 Dormant (off) State. To determine conformance to 3.6.6.1 the following test shall be performed while the battery is in the Operational State. The mating connector P1 shall be disconnected from the battery communication interface J1, and the battery terminal voltage shall be monitored to verify the transition time to the Dormant State does not exceed 10 seconds.

4.5.6.2 Initialize State. To determine conformance to 3.6.6.2 the battery terminal voltage shall be monitored as it transitions from the Dormant State to the Operational State to verify that the transition time does not exceed 10 seconds.

4.5.6.3 Operational State. To determine conformance to 3.6.6.3, the battery shall be monitored for the conditions of the Operational State. It shall be verified that the battery provides electrical power at the terminals, CAN messages are reported in response to a RQST and configuration messages, CAN messages are reported on a regular interval when the master power switch is “On”, and CAN messages are not reported on a regular interval when the master power switch is “Off”. It shall also be verified that the time to report battery voltage, battery current, battery internal temperature, state of charge, state of health, time remaining, and BIT results does not exceed 500 milliseconds when entering the Operational State with the master power switch “On” or when in the Operational State and the master power switch changes from “Off” to “On”.

4.5.6.4 Maintenance State. To determine conformance to 3.6.6.4, the battery shall be sent the battery configuration message with Maintenance State parameter with value set to “Enter Maintenance State,” and verify battery provides the positive acknowledgement message. Once in Maintenance State, the battery shall be sent the Maintenance State parameter with value set to “Exit Maintenance State,” and verify the battery provides the positive acknowledgement message.

4.5.6.5 Protected State. To determine conformance to 3.6.6.5, the battery shall be monitored in 4.10.2.1, 4.10.2.2, 4.10.2.3, 4.10.2.4, and 4.10.2.5 to verify battery transitions to and from the Protected State.

4.5.7 Built-in tests.

4.5.7.1 Power-up BIT. To determine conformance to 3.6.7.1, the battery PBIT results shall be verified after the battery has transitioned out of the Initialize State.

4.5.7.2 Continuous BIT. To determine conformance to 3.6.7.2, the battery shall be monitored in the Operational State to verify that the battery reports the CBIT results.

4.5.7.3 BIT diagnostics probability. Vendor certification that battery is compliant with 3.6.7.3 is required.

4.5.8 Long term fault data storage (non-volatile). To determine conformance to 3.6.8, the battery manufacturer shall provide a method to determine if long term fault data has been stored successfully in non-volatile memory, sufficient to support a 96 hour mission.

4.5.9 Short term fault data storage (volatile). To determine conformance to 3.6.9, the battery manufacturer shall provide a method to determine if short term fault data has been stored successfully in volatile memory.

4.6 Surges, spikes and disturbances.

4.6.1 Voltage surges. To determine conformance to 3.7.1, test as specified in MIL-STD-1275.

4.6.2 Voltage spikes. To determine conformance to 3.7.2, test as specified in MIL-STD-1275.

4.6.3 Starting disturbance. To determine conformance to 3.7.3, test as specified in MIL-STD-1275.

4.6.4 Starting current. Vendor certification that battery is compliant with 3.7.3.1 is required.

4.6.5 Steady state surges. To determine conformance to 3.7.4, test as specified in MIL-STD-1275.

4.6.6 Steady state spikes. To determine conformance to 3.7.5, test as specified in MIL-STD-1275.

4.7 Environmental.

4.7.1 Altitude.

4.7.1.1 Altitude, operating & non-operating. Each battery listed for altitude testing in table VII shall undergo all steps listed in this test section. To determine conformance to 3.8.1.1, the following test shall be performed:

a. Perform the full charge capacity test of 4.4.6.1.

b. Charge according to 4.4.9.

c. Weigh the battery.

d. Run the test specified in the operating section of ATPD 2404.

e. Stabilize at 22±5 °C for 6 hours.

f. Perform and verify the battery meets the requirements of the full charge capacity test of 4.4.6.1.

g. Weigh the battery.

h. Repeat steps a. through g., instead running the test specified in the non-operating section of ATPD 2404.

4.7.1.2 Rapid decompression. To determine conformance to 3.8.1.2, perform the following tests:

a. Perform the full charge capacity test of 4.4.6.1.

b. Charge according to 4.4.9.

c. Weigh the battery.

d. Run the test specified in the rapid decompression section of ATPD 2404.

e. Perform the full charge capacity test of 4.4.6.1.

f. Charge according to 4.4.9.

g. Weigh the battery.

4.7.2 Attitude. To determine conformance to 3.8.2, perform the following test:

a. Invert the battery from its normal upright position (see 6.3.28).

b. Perform the full charge capacity test of 4.4.6.1.

4.7.3 Thermal shock. To determine conformance to 3.8.3 the following test shall be performed:

a. Perform the full charge capacity test of 4.4.6.1.

b. Charge according to 4.4.9.

c. Run the test specified in the temperature shock section of ATPD 2404.

d. Perform full charge capacity test of 4.4.6.1.

4.7.4 Mechanical Shock. To determine conformance to 3.8.4 the following test shall be performed.

a. Perform the full charge capacity 4.4.6.1.

b. Charge according to 4.4.9.

c. Rigidly attach the batteries to the test carriage by mounting screws or other appropriate hardware and shall perform a shock test with not less than 40G with a pulse duration of not less than 18 milliseconds in accordance with the functional shock section of ATPD 2404.

d. Apply three shocks per axis, on each of three orthogonal axis.

e. Perform the full charge capacity 4.4.6.1.

4.7.5 Vibration. To determine conformance to 3.8.5, the following test shall be performed:

a. Perform the full charge capacity 4.4.6.1.

b. Charge according to 4.4.9

c. Perform vibration tests according to the vibration section of ATPD 2404.

d. Perform the full charge capacity 4.4.6.1.

4.7.6 Immersion. To determine conformance to 3.8.6 the following test shall be performed after the terminal posts and threaded sockets test is complete (see 3.3.3.1 and 4.4.2.4.1).

a. Charge battery in accordance with 4.4.9.

b. Weigh the battery.

c. Run the test specified in the leakage (immersion) section of ATPD 2404.

d. After immersion, remove the batteries and dry exterior surfaces. Weigh the battery.

e. Discharge the battery according to 4.4.6.1 d.

4.7.7 Humidity. To determine the conformance to 3.8.7 the following test shall be performed:

a. Perform the full charge capacity 4.4.6.1.

b. Charge battery in accordance with 4.4.9.

c. Perform test in the subsystem operational section of ATPD 2404.

d. The operational check shall be performed according to the full charge capacity test in 4.4.6.1.

4.7.8 Blowing sand and dust. To determine the conformance of 3.8.8 the following test shall be performed:

a. Conduct the dust test in accordance with the blowing sand internal and blowing dust internal sections of ATPD 2404.

b. Perform the full charge capacity 4.4.6.1, and check voltage (see 3.5.3).

4.7.9 Salt atmosphere. To determine the conformance of 3.8.9 the following test shall be performed.

a. Perform the full charge capacity 4.4.6.1.

b. Charge the battery in accordance with 4.4.9.

c. Perform the test in the salt fog section of ATPD 2404.

d. Perform the full charge capacity 4.4.6.1.

4.7.10 Fluid susceptibility. To determine the conformance of 3.8.10, the following test shall be performed.

a. Perform the full charge capacity 4.4.6.1.

b. Charge the battery in accordance with 4.4.9.

c. Conduct the fluid susceptibility test in accordance with the contamination by fluids section of ATPD 2404.

d. Perform the full charge capacity 4.4.6.1.

4.7.11 Explosive atmosphere. To determine conformance of 3.8.11, the battery shall be subjected to the test method described in the explosive atmosphere section of ATPD 2404, while undergoing a charge as described in 4.4.9 without the igniting of the air-vapor mixture.

4.8 Electromagnetic compatibility/interference. To determine the conformance of 3.9, the following test shall be performed.

a. Perform the full charge capacity 4.4.6.1.

b. Charge the battery in accordance with 4.4.9.

c. Perform the following test procedures of CE102, CS101, CS114, CS115, CS116, RE102, and RS103 with 1 meter cables from MIL-STD-461.

d. Perform the full charge capacity 4.4.6.1.

4.9 Electrostatic discharge. To determine conformance of 3.10, the following test shall be performed.

a. Subject the batteries to the contact discharge test of IEC 61000-4-2, Level 4, to include contact with all non-electrically conductive external portions of the battery. This includes, but is not limited to, each connector, connector shield, and the battery case. The battery shall be tested with no load and undergoing a 1C load.

b. Verify that the load can be sustained for 1 minute following the test.

c. Verify communications in accordance with 4.4.1.

d. Perform the full charge capacity test in accordance with 4.4.6.1, and compare results to the requirements of 3.5.4.

4.10 Safety.

4.10.1 Cell safety.

4.10.1.1 Cell safety abuse tests. Vendor shall certify that cells used for the battery have been characterized in accordance with SAE J2464 for the tests specified below. Vendor shall report corresponding Hazard Severity Level to the Government.

4.10.1.1.1 Cell overcharge. To determine conformance to 3.11.1.1.1 perform test in accordance with the Overcharge Test (Cell and Module or Pack) section of SAE J2464.

4.10.1.1.2 Cell short circuit. To determine conformance to 3.11.1.1.2 perform test in accordance with the Short Circuit Tests (Cell and Module or Pack) section of SAE J2464.

4.10.1.1.3 Cell over discharge. To determine conformance to 3.11.1.1.3 perform test in accordance with the Overdischarge (Forced Discharge) Test (Cell Level and Module) section of SAE J2464.

4.10.1.1.4 Cell penetration. To determine conformance to 3.11.1.1.4 perform test in accordance with the Penetration Test (Cell Level or Above) section of SAE J2464, at a minimum of 100 and 50 percent state of charge.

4.10.1.1.5 Cell crush. To determine conformance to 3.11.1.1.5 perform test in accordance with the Crush Test (Cell Level or Above) section of SAE J2464.

4.10.1.2 Cell leakage. To determine conformance to 3.11.1.2, the vendor shall certify that the following test has been successfully completed. Any mass loss or visual defects shall be reported.

a. Fully charge the cells in any appropriate manner at the normal conditions of 4.3.1.1.

b. Weigh each cell to the nearest tenth of a milligram.

c. Store cells at 60±3 °C for not less than 622 hours (approximately 26 days).

d. Remove from high temperature storage and stabilize cells at the normal conditions of 4.3.1.1 for not less than 1 hour.

e. Weigh each cell to the nearest tenth of a milligram.

4.10.2 Battery safety.

4.10.2.1 Battery over- current protection. To determine conformance to 3.11.2.1., the following test shall be performed.

a. Perform the full charge capacity test (see 4.4.6.1).

b. Charge the batteries as specified in 4.4.9 .

c. Short each battery across each pair of positive and negative terminals through an external resistance. External resistance shall be 10±3 milliohms. The resistance shall be removed from the terminals 1 hour after short occurs.

d. Measure and record the battery open circuit voltage (OCV).

e. Stabilize batteries at the normal conditions of 4.3.1.1 for not less than 2 hours.

f. Check voltage (see 3.5.3).

g. Perform the full charge capacity (see 4.4.6.1).

4.10.2.2 Battery overcharge protection. To determine conformance to 3.11.2.2.2, the following test shall be performed.

a. Perform the full charge capacity test (see 4.4.6.1).

b. Charge batteries in accordance with 4.4.9.

c. Apply a voltage of 125 percent of the top of charge voltage (41.25 volts) for no less than 1 hour, while measuring and recording battery voltages continuously or at a sampling rate of not less than once per 60 seconds.

d. Stabilize batteries at normal conditions for not less than 2 hours.

e. Perform the full charge capacity (see 4.4.6.1).

4.10.2.3 Battery over-discharge protection. To determine conformance to 3.11.2.3, the following test shall be performed.

a. Perform the full charge capacity test (see 4.4.6.1).

b. Charge batteries in accordance with 4.4.9.

c. Attempt to over-discharge the batteries at a rate of C/2 below the battery's terminal cutoff voltage.

d. Measure and record battery voltages continuously or at a sampling rate of not less than once per 60 seconds.

e. Stabilize batteries at normal conditions for not less than 2 hours.

f. Charge the batteries in accordance with 4.4.9.

g. Perform the full charge capacity test (see 4.4.6.1).

4.10.2.4 Battery over temperature protection. To determine conformance to 3.11.2.4 the following test shall be performed:

a. Charge battery in accordance with 4.4.9.

b. Stabilize the battery at 71±3 °C for not less than 6 hours.

c. Verify the battery is in the Operational State.

d. Raise the temperature to above specific manufacturer's over temperature limit.

e. Verify the battery has transitioned to the Protected State once the reported internal temperature is at or above the manufacturers defined over temperature limit.

f. Measure and record the battery voltage (see 3.5.3).

g. Place battery in an ambient temperature of 22±5 °C and verify that the battery has returned to the Operational State once the reported internal temperature is below the manufacturers defined over temperature limit.

h. Perform the full charge capacity test (see 4.4.6.1).

4.10.2.5 Battery low temperature charge protection. To determine conformance to 3.11.2.5 vendor certification required.

4.10.2.6 Battery impact resistance (non-metallic battery case only). To determine the conformance to 3.11.2.6 the following test shall be performed.

a. Condition the empty battery case for at least 4 hours at 71±3 °C.

b. Place the battery case on a flat steel plate, which is not less than 25 cm longer and wider than the case.

c. Drop a free-falling 0.907±0.023 kg solid steel ball one time on the center of every face of the battery case from a height of 2.29 m.

d. Examine the battery case in accordance with 4.4.2.2.

e. Repeat step a. through d. with a different battery case but use a temperature of -18±3 °C and a height of 1.52 m.

f. Repeat step a. through d. with a different battery case but use a temperature of -40±3 °C and a height of 1.27 m.

4.10.2.7 Battery abuse.

4.10.2.7.1 Battery crush. To determine the conformance to 3.11.2.7.1 the battery shall be characterized in accordance with the Crush Test (Cell Level or Above) section of SAE J2464. Record corresponding Hazard Severity Level.

4.10.2.7.2 Battery penetration. To determine conformance to 3.11.2.7.2 the following tests shall be performed.

4.10.2.7.2.1 Battery nail penetration. The battery shall be characterized in accordance with the penetration test (Cell Level or Above) section of SAE J2464. Record corresponding Hazard Severity Level.

4.10.2.7.2.2 Battery projectile penetration. Two samples, one for test A and one for test B shall be tested as follows:

a. Charge battery in accordance with 4.4.9.

b. Secure the battery in an upright position to prevent battery movement during testing, and in a manner that shall not impede path of the projectiles.

c. Battery shall be placed on a resistive load of 30±3 ohms no more than 5 minutes before the first shot, and remain on the resistive load until conclusion of the test.

d. Three projectiles shall be fired at the test battery with no more than 90 seconds between the first and third projectile at ambient conditions. Muzzle velocity of the projectiles shall be 728±244 meters per second (mps).

e. For each test listed below, record the date, time, place, ambient temperature, battery voltage (not less often than once per second), temperature of the positive and negative terminal posts (not less often than once per second), any events (smoke, fire, cell activity, or disassembly) along with the event time and associated event severity, and the corresponding Hazard Severity Level.

(1) Test A. The battery shall be shot three times with 7.62 mm armor piercing incendiary (API) projectiles. Each projectile shall be at a 90° angle from the side of the battery along axis 2 (see figure 12). The impact area for the battery shall be at least 40 mm from each edge of the battery (see figure 13.). Each projectile shall be at least 50 mm on center from each of the other two projectiles when striking the side of the battery.

(2) Test B. The battery shall be shot three times with 7.62 mm armor piercing incendiary (API) projectiles. Each projectile shall be at a 90° angle from the front of the battery along axis 1 (see figure 12). The impact area for the battery shall be at least 40 mm from each edge of the battery (see figure 13.). Each projectile shall be at least 50 mm on center from each of the other two projectiles when striking the front of the battery.

All battery projectile penetration testing shall be videoed at not less than 1080p 30 frames per second. Recordings shall continue for 2 hours or until:

a. Hazard Severity Level 6 is exceeded for a Type I.

b. Hazard Severity Level 6 is exceeded for a Type II and III.

4.10.2.7.3 Battery drop low height. To determine conformance to 3.11.2.7.3 the following test shall be performed:

a. Perform the full charge capacity test (see 4.4.6.1).

b. Charge battery in accordance with 4.4.9, then place batteries in the Dormant State.

c. Stabilize the battery at 85±3 °C for at least 6 hours.

d. Perform the drop at ambient conditions within 10 minutes of step c.

e. The fully charged, upright battery shall be dropped from a height of 30 cm measured from the lowest point of the battery onto a concrete surface (see 6.3.28). The bottom of the battery shall be parallel to the concrete surface before being dropped.

f. Wait 24 hours.

g. Perform the full charge capacity test 4.4.6.1.

h. Charge battery in accordance with 4.4.9.

i. Stabilize the battery at 85±3 °C for at least 6 hours.

j. Perform the drop at ambient conditions within 10 minutes of step i.

k. The fully charged battery shall be suspended from one handle at a height of 30 cm from the lowest point of the battery. The battery shall then be dropped onto a concrete surface.

l. Wait 24 hours.

m. Perform the full charge capacity test 4.4.6.1.

n. Repeat steps a. through m. but at -51±3 °C with the same battery.

4.10.2.7.4 Battery drop high height. To determine conformance to 3.11.2.7.4 the following test shall be performed.

a. Charge battery in accordance with 4.4.9.

b. Stabilize the battery at 85±3 °C for at least 6 hours.

c. Perform the drop at ambient conditions within 10 minutes of step b.

d. A fully charged battery shall be dropped, inverted from its normal upright position, on the top face of the battery with both positive and negative terminal posts installed (see 6.3.28). The drop shall be from a height of 2 m measured from the lowest point of the inverted battery. The drop shall be performed on a concrete surface. The top of the battery shall be parallel to the concrete surface before being dropped.

e. Wait 24 hours.

f. Record corresponding Hazard Severity Level in accordance with the Hazard Severity Levels and descriptions table of SAE J2464.

g. Repeat steps a. through g. but at -51±3 °C with a different battery.

4.11 Lithium battery safety program (U.S. Navy). To determine conformance to 3.12, batteries shall be tested in accordance with S9310-AQ-SAF-010. S9310-AQ-SAF-010 is required for 6T Li-ion battery qualification inspection. The test data provided from the testing will be used to evaluate applications for specific devices and Navy platforms. Devices using this battery will require U.S. Navy safety approval prior to use by Department of Navy users unless such approval has already been granted. Consult with NAVSEA Instruction 9310.1 for further information.

4.12 Charger compatibility. To determine conformance to 3.13, the batteries shall be connected to a MIL-STD-1275 compliant charger. Verify no anomalies occur during operation and charging of the batteries.

4.13 Workmanship. To determine conformance to 3.14, an engineering analysis (see 4.4.1) shall be conducted.

4.14 Product characteristics.

4.14.1 Paint, protective finishes, and coatings. To determine conformance to 3.15.1 an engineering analysis (see 4.4.1) shall be conducted.

4.14.2 Corrosion resistance. To determine conformance to 3.15.2 an engineering analysis (see 4.4.1) shall be conducted. This analysis shall consider corrosion between lead battery clamps and the terminal posts.

4.14.3 Restricted materials.

4.15 Electronic assemblies. To determine conformance to 3.16 an engineering analysis (see 4.4.1) shall be conducted.

4.16 Hazardous materials. To determine conformance to 3.17 an engineering analysis (see 4.4.1) shall be conducted.

4.17 CBRN. To determine conformance to 3.18 an engineering analysis (see 4.4.1) shall be conducted.

4.18 Defects. To determine conformance to 3.19, conduct a visual inspection (see 4.4.2) or measurement with standard inspection equipment.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The batteries covered by this specification are used in a variety of military land vehicles, aircraft, seagoing vessels, electronic and communications equipment, and for other military power requirements. The batteries are capable of storage and use under wide temperature ranges and are subjected to severe environmental conditions, including exposure for prolonged periods to extreme seagoing environments not encountered in civilian applications.

6.2 Acquisition requirements. Procurement documents should specify the following:

a. Title, number, and date of the specification.

b. Assist online database should be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1).

c. Whether or not IUID is required (see 3.4.3.2).

d. If a lead-free control plan is required (see 3.16.2).

e. If approval is required (see 3.17).

f. A list of defects for which rework is permitted (see 3.19).

g. If IPI is not required (see 4.1.2.1).

h. Special packaging requirements, other than those specified (see 5).

i. Shelf life requirements (see 6.10).

*Note. It is recommended that defects in categories 003, 007, 009, 102, 103, 104, 105, 106, 107, 108, 201, and 202 of table VI be permitted to be reworked during Group A Inspection and that the list be included in the contract.

6.3 Definitions.

6.3.1 Amp hour or ampere-hour. A unit of measurement of a battery's electrical storage capacity. Current multiplied by time in hours equals ampere-hours. One amp hour is equal to a current of one ampere flowing for one hour. Also, 1 amp hour is equal to 1,000 mAh.

6.3.2 Battery. An electrochemical device used to store energy. The general term for a single cell, or a group of cells connected together either in a series or parallel configuration.

6.3.3 Battery capacity. The number of ampere-hours which can be delivered by a battery on a single (dis)charge. The battery capacity is determined by a number of factors, including the cutoff voltage, discharge rate, temperature, method of charge and the age and life history of the battery.

6.3.4 Battery case. The battery case is defined as all parts of the outer protective covering (including battery cover or lid, if present) in which the completed cell assembly is contained.

6.3.5 Battery, lithium-ion. The lithium-ion (or Li-ion) battery is a rechargeable battery characterized by lithium ions moving through the electrolyte from the negative electrode to the positive electrode in discharging and reverse when charging. The negative electrode is made from insertion material (examples include hard carbon or graphite) and the electrolyte is a lithium salt in an organic solvent. The positive electrode consists of a material where lithium ions can be reversibly inserted and removed.

6.3.6 Battery, secondary. A battery that is intended to be discharged and recharged many times in accordance with the manufacturer's recommendations.

6.3.7 Battery service life. The expected calendar life of the battery when installed as new and operated under normal conditions (see 4.3.1.1).

6.3.8 C rate. A C-rate is a current rate (in amperes) at which a fully charged battery is fully discharged in one hour. Thus, C rate for a 100 Ah battery would be 100 A. Different multiples of the C rate are calculated by multiplying a factor by the C rate. For example for a 100 Ah battery, 2C rate would be 200 A, C/5 rate would be 20 A and C/10 would be 10 A. For the tests in this specification, C rates are based on the full charge capacity in table I.

6.3.9 Cell. An electrochemical device, composed of positive and negative electrodes and electrolyte, which is capable of storing electrical energy.

6.3.10 Charge. The conversion of electric energy, provided in the form of a current, into chemical energy within the cell or battery.

6.3.11 Charge rate. The current in amperes at which the battery is charged.

6.3.12 Completed cell assembly. The total number of cells used within a complete battery along with the intercell connections.

6.3.13 Contactor. A reusable device that interrupts the flow of electric current. A contactor may be an electromechanical or a solid-state electrical device, which is actuated by an on/off control signal.

6.3.14 Cutoff voltage. The prescribed lower-limit voltage at which battery discharge is considered complete.

6.3.15 Cranking. Attempting to start a vehicle's engine by energizing the electric starter with a power pulse.

6.3.16 Cycle. One sequence of charge and discharge.

6.3.17 Cycle, deep. A cycle in which the discharge is continued until the battery reaches its cutoff voltage, 100 percent depth of discharge.

6.3.18 Cycle life. For rechargeable batteries, the total number of charge/discharge cycles the cell can sustain before its capacity is significantly reduced. End of life is usually considered to be reached when the cell or battery delivers only 80 percent of rated ampere-hour capacity. The cycle of a battery is greatly influenced by the depth of the discharge and the method of recharging.

6.3.19 Discharge. The conversion of the chemical energy of the battery into electric energy.

6.3.20 Discharge rate. The current in amperes at which the battery is discharged.

6.3.21 Electrode. An electrical conductor through which an electric current enters or leaves a conducting medium. In a cell, an electrode is an electrical conductor at the surface of which a change occurs from conduction by electrons to conduction by ions.

6.3.22 Electrolyte. The ionically conductive material within a battery which transports charged atoms (ions) between the electrodes. Lithium-ion batteries most commonly use an electrolyte comprised of lithium salt in an organic solution.

6.3.23 Energy. Expressed as capacity in ampere-hours times the battery voltage, or watt-hours.

6.3.24 Energy density. The ratio of cell energy to volume (Watt-hours per liter). The term 'energy density' is also commonly used for the ratio of cell energy to mass (Watt-hours per kilogram), although the more accurate term for this characteristic is 'specific energy.'

6.3.25 Fully charged batteries. Batteries will be considered fully charged when charged in accordance with 4.4.9.

6.3.26 Fully discharged batteries. A fully discharged battery or cell will have been discharged to show an output of voltage equal to its cutoff voltage.

6.3.27 Negative terminal. The terminal of a battery from which electrons flow in the external circuit during discharge.

6.3.28 Normal upright position. The battery case orientated with the threaded sockets (terminals) facing upwards with respect to the earth's surface.

6.3.29 Open circuit. The condition of a battery which is neither on charge nor on discharge (as in, disconnected from a circuit).

6.3.30 Open-circuit voltage. The difference in potential between the terminals of a battery when the circuit is open (a no-load condition).

6.3.31 Positive terminal. The terminal of a battery toward which electrons flow through the external circuit during discharge.

6.3.32 Power. The (dis)charge rate in amperes multiplied by battery voltage in volts, or watts.

6.3.33 Power density. The power in watts divided by the volume in liters of the battery.

6.3.34 Rework. Correcting of defective, failed, or nonconforming items, during or after inspection. Rework includes all follow-on efforts such as disassembly, repair, replacement, re-assembly, etc.

6.3.35 Seal. A device or substance that is used to join two things together so as to prevent them from coming apart or to prevent anything from passing between them.

6.3.36 Self-discharge. Discharge that takes place while the battery is in an open-circuit condition.

6.3.37 Shelf life. The period of time (measured from date of manufacture) at a storage temperature, after which the battery retains a specified percentage of its original energy content.

6.3.38 Softening temperature. The softening temperature of insulation is the temperature at which it will distort under a reasonable amount of pressure when tested in accordance with the heat distortion test of ASTM D2633.

6.3.39 State of charge. The ratio of the amount of capacity remaining in a battery to the present full charge capacity. A battery at 25 percent state of charge has 25 percent capacity remaining versus what it could give if fully charged.

6.3.40 State of health. State of health (SoH) is the ratio of the present health of the battery compared to a new battery. Capacity and power capability are parameters usually associated with battery health. Example: If actual battery capacity has degraded to 80 percent of the nameplate capacity, the SoH would be considered 80 percent. The end of life SoH will be determined by the vehicle platform.

6.3.41 Terminals. A point at which current enters or leaves a cell, battery, or circuit. The parts of a cell, battery, or circuit to which the external electric circuit is connected.

6.3.42 Voltage, nominal. A reference voltage used to describe batteries or cells.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Products List QPL No. 32565 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from U.S. Army Tank Automotive Research, Development and Engineering Center, ATTN: Energy Storage Team, RDTA-RS, (MS #121), Warren, MI 48397-5000. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at https://assist.dla.mil.

6.5 Manufacturing. Based on the test and field history of Government battery procurements, control of the following processes in production are critical to the safe performance of the batteries delivered to the Government:

a. Control of contaminants in basic cell components.

b. Control of the electrolyte mixing process to ensure no contaminants are introduced, no overheating occurs during mixing, and each batch contains the proper proportions of each component.

c. Control of the minimum amount of carbon needed in each positive electrode. Control of electrode alignment during the core winding operation for circular cells.

d. Avoiding use of tapes or sealing methods on the electrode core wind (or "jelly roll") as a means of facilitating automated assembly operations. Sealing of the core wind results in excessive stress on cell internal connections during vibration testing.

e. Providing strong weld adhesion of the positive tab inside the cell and adequate stress relief on the positive electrode tab inside each cell, to include restricting re-work of rejected weld connections.

f. Control of all cell closure processes, including the control of weld burrs that could damage insulating materials inside batteries.

g. Controls for weld burrs on cell top-shell welds with a potential to cut through cell insulation and shorting a cell against an adjacent cell.

h. Assurance that heat-shrink insulating materials will perform as specified and control of their application to ensure proper insulation.

i. Control of the sealing process for battery cases to ensure the watertight integrity of the battery.

6.6 Specification content. Users of this document are cautioned that experience has shown the need to assess the safety characteristics and safety assurance needs of each Li-ion battery electro-chemistry independently prior to establishing the minimum requirements for safety assurance. The system safety risk assessment techniques of MIL-STD-882 are recommended as a source for determining the safety assurance needs of Li-ion battery electro-chemistries.

6.7 Cell traceability. A traceability system for battery cells should be maintained. All cells delivered individually or as part of a battery to this specification should be identified such that they are traceable through a manufacturer identification number, or other identification marking, through which the manufacturing date, lot code, cell chemistry, or other applicable information can be determined.

6.8 Product traceability (battery). A traceability system for batteries or battery lots should be maintained. The traceability system should include, as a minimum, the completion of each step required in the design (when applicable), fabrication, assembly, test and any applicable qualified rework procedure. Further, traceability should be maintained in order to determine that batteries have passed the applicable screening, qualification, and quality conformance inspections.

6.9 Safety data sheets. Contracting officers will require copies of completed safety data sheets prepared in accordance with FED-STD-313. The pertinent Government mailing addresses for submission of data are listed in FED-STD-313. Note that 29 CFR 1910.1200 requires that the safety data sheet for each hazardous chemical used in an operation must be readily available to personnel using the material.

6.10 Shelf life. This specification covers items where the assignment of a Federal shelf-life code is a consideration. Specific shelf-life requirements should be specified in the contract or purchase order, and should include, as a minimum, shelf-life code, shelf-life package markings in accordance with MIL-STD-129 or FED-STD-123, preparation of a materiel quality storage standard for type II (extendible) shelf-life items, and a minimum of 85 percent shelf-life remaining at time of receipt by the Government. These and other requirements, if necessary, are in DoD 4140.27-M, Shelf-life Management Manual. The shelf-life codes are in the Federal Logistics Information System Total Item Record. Additive information for shelf-life management may be obtained from DoD 4140.27-M, or the designated shelf-life points of contact (POC). The POC should be contacted in the following order: the Inventory Control Points that manage the item then the DoD Service and Agency administrators for the DoD Shelf-Life Program. Appropriate POCs for the DoD Shelf-Life Program can be contacted through the DoD Shelf-Life Management website: https://www.shelflife.hq.dla.mil/.

6.11 Transportation. All transportation of Li-ion cells and batteries in the public domain is controlled by federal law regulating shipment of hazardous materials. The general regulations are stated in 49 CFR 172.101 and 173.185. Any deviation from the methods described in the CFR must be approved before shipment in the form of an "Exemption" by the Office of Hazardous Material Safety Research and Special Programs Administration, U.S. Department of Transportation, Washington, DC 20590.

6.12 Shipping safety. Each battery should be shipped in accordance with safety requirements per Department of Transportation (DOT) & United Nations (UN) regulations.

6.13 Battery condition for shipping.

6.13.1 Operating and charging instructions. Each battery should be furnished with complete instructions for storage, handling, maintenance, operation and charging of the battery including preferred and alternate charging methods. A safety data sheet (SDS) should also be furnished.

6.13.2 Caps for protection. Batteries should be supplied with a cap over the CAN port, the threaded sockets, and the terminal posts, if installed, for shorting prevention and dust resistance. The cap should be snug-fitting and should be removable by hand at temperatures listed below. The material used for the cap should be non-toxic, non-flammable and non-conductive and should withstand temperatures from -54 to 88 °C without shrinkage or cracking. The cap should not leave any residue on the battery contacts nor have any adverse effect on the connection interface. They should also act to insulate terminals/leads from accidental shorting. The cap should be either black, closely match the color of the battery, or represent the terminal colors (red = positive, & black = negative). Cap compliance to these requirements should be vendor certified. The caps should also prevent dust entry.

6.13.3 Maintenance. After delivery from the manufacturer, batteries should not require the addition of any electrolyte nor require any maintenance in meeting the provisions of this specification. However, they may still require a charge before initial issue because of long storage times and self-discharge. The battery may require capacity checks, charging before initial issue, and recharging after deep discharge.

6.13.4 Age documentation. The manufacturer should provide certification with each delivery of cells or batteries in order to meet the following:

a. The maximum age of cells or cells assembled into batteries, from the time of their initial manufacture to the time of their assembly into batteries should not be greater than 180 days.

b. Batteries or cells should be submitted for Government testing within 30 days of battery assembly.

6.14 Transportation. Batteries and cells should be tested in accordance with applicable U.S. DOT & U.N. Manual of Tests and Criteria shipping regulations and meet the requirements therein.

6.15 Verification inspection. Verification by the Government will be limited to the amount deemed necessary to determine compliance with the contract and will be limited in severity to the definitive quality assurance provisions established in this specification and the contract. The amount of verification inspection by the Government will be adjusted to make maximum utilization of the contractor's quality control system and the quality history of the product.

6.16 Inspection lot. The inspection lot is the quantity of batteries (exclusive of the number of batteries required as samples) produced at any one place of manufacture on any one contract presented to the Government for acceptance. The formation of lots, batches, their size, and the manner in which each lot or batch is to be presented and identified by the supplier should be designated or approved by the Government.

6.17 Test report data. Test report data will be specified in the contract in accordance with MIL-STD-961. The following data points will be necessary for Government review and should be included in first article and conformance test reports:

a. Certifications, where required.

b. Whenever there is a service or ampere hour requirement, include the following:

(1) Initial open circuit voltage (IOCV)
(2) Initial loaded voltage (ILV)
(3) Battery or cell voltage, current, capacity, energy, and temperature recorded at regular intervals. Interval should be service requirement or shorter.
(4) The time elapsed between initial voltage and final voltage.

c. Record how low a battery is discharged in volts, particularly whenever near zero volts.

d. Record the charge and discharge rates and voltage limits.

e. Record date and time that any portion of test is initiated in the test report including initiation and duration of soak at test temperature.

f. When a requirement limit is specified, record the final quantitative figure.

6.18 Lithium battery safety program (U.S. Navy). Potential offerors and contractors should be aware that passing the test criteria specified herein for the U.S. Navy Lithium Battery Safety Program will not constitute a safety approval for the battery by the U.S. Navy. In accordance with S9310-AQ-SAF-010, Navy department users must still apply for battery safety approvals based on the NSN of the battery intended for use, as well as both the intended Navy platform and each specific using end item.

6.18.1 Test data. The intent of including U.S. Navy Lithium Battery Safety Program requirements in this specification are primarily to give manufacturers visibility into the essential safety characteristics needed by the U.S. Navy. Until now, the tests were performed in evaluating system or device safety without any knowledge of these requirements by battery manufacturers. Additionally, these requirements will provide the Navy with test data on file when assessing applications for safety approvals. The data provided will be used for engineering assessments that are capable of providing recommendations for safer battery compartments in battery-using devices.

6.18.2 Test vessel. Due to the need to record pressure changes during test, the Navy safety tests require use of a test “vessel”, defined as a sealed container larger than the battery under test. A calculation of the remaining void space inside the vessel containing the battery under test will be needed for proper interpretation of the pressure readings.

6.18.3 Navy test facility. The Department of Defense has a preference for having the tests described by S9310-AQ-SAF-010 conducted in a U.S. Navy test facility. Potential offerors are cautioned to review solicitations for such requirements. Should testing at a Navy facility be required, offerors will need to obtain a quote for Navy testing in order to respond to the solicitation. Points of contact in the Navy for the quote will be identified in the solicitation documentation. Offerors will need to assure that Navy testing costs are covered in their price proposal.

6.19 Environmentally preferable material. The U.S. Environmental Protection Agency (EPA) is focusing efforts on reducing hazardous or environmentally unfriendly chemicals. The list of chemicals and additional information is available on their website at http://www.epa.gov/osw/hazard/wastemin/priority.htm. Included in the list are cadmium, lead, and mercury. Use of the materials on the list should be minimized or eliminated unless needed to meet the requirements specified herein.

6.20 Subject term (key word) listing.

24V
Deep Cycle
Automotive
Battery Management System
Li-ion
Starting Lighting Ignition
Cranking

6.21 Additional reference materials. The following reference materials may be beneficial to the user:

a. MIL-DTL-53039, Coating, Aliphatic Polyurethane, Single Component, Chemical Agent Resistant

b. MIL-DTL-64159, Coating, Water Dispersible Aliphatic Polyurethane, Chemical Agent Resistant

c. MIL-STD-1686, Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

d. MIL-HDBK-454, General Guidelines for Electronic Equipment

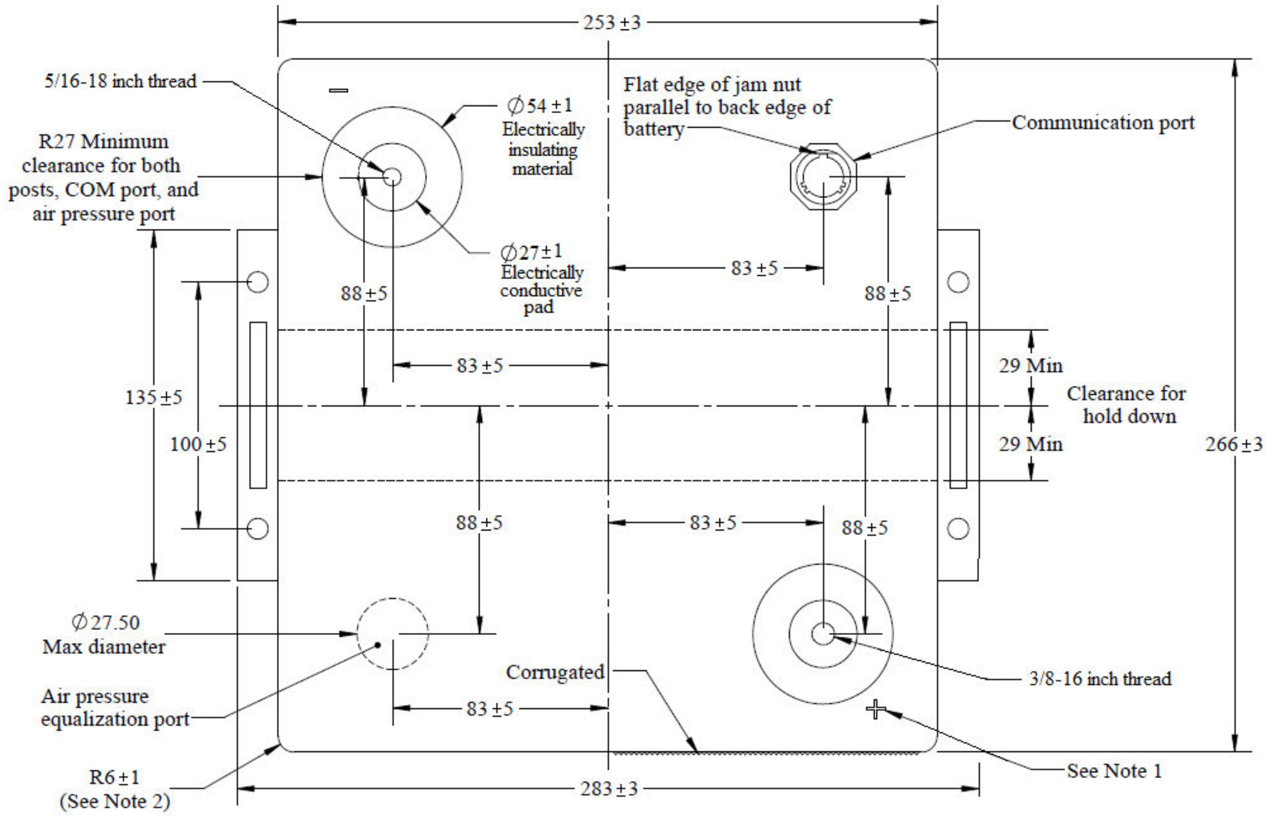
e. 49 CFR 173.159, Batteries, Wet

f. IPC-2222, Sectional Design of Rigid Organic Printed Boards

g. SAE J537, Storage Batteries (DoD Adopted)

h. SAE J930, Storage Batteries for Off -Road Work Machines

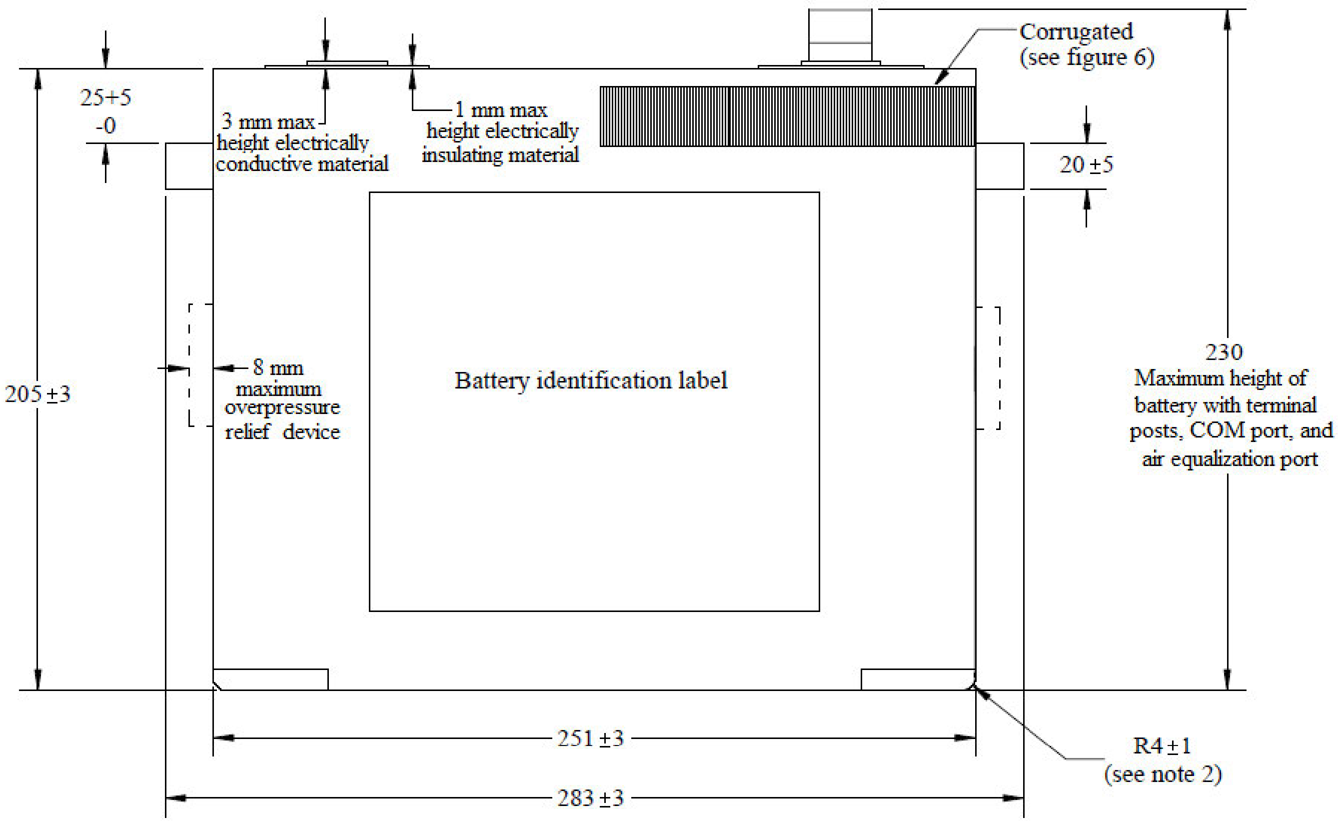
i. SAE J2284-2, High Speed CAN (HSC) for Vehicle Applications at 250 Kbps



NOTES:

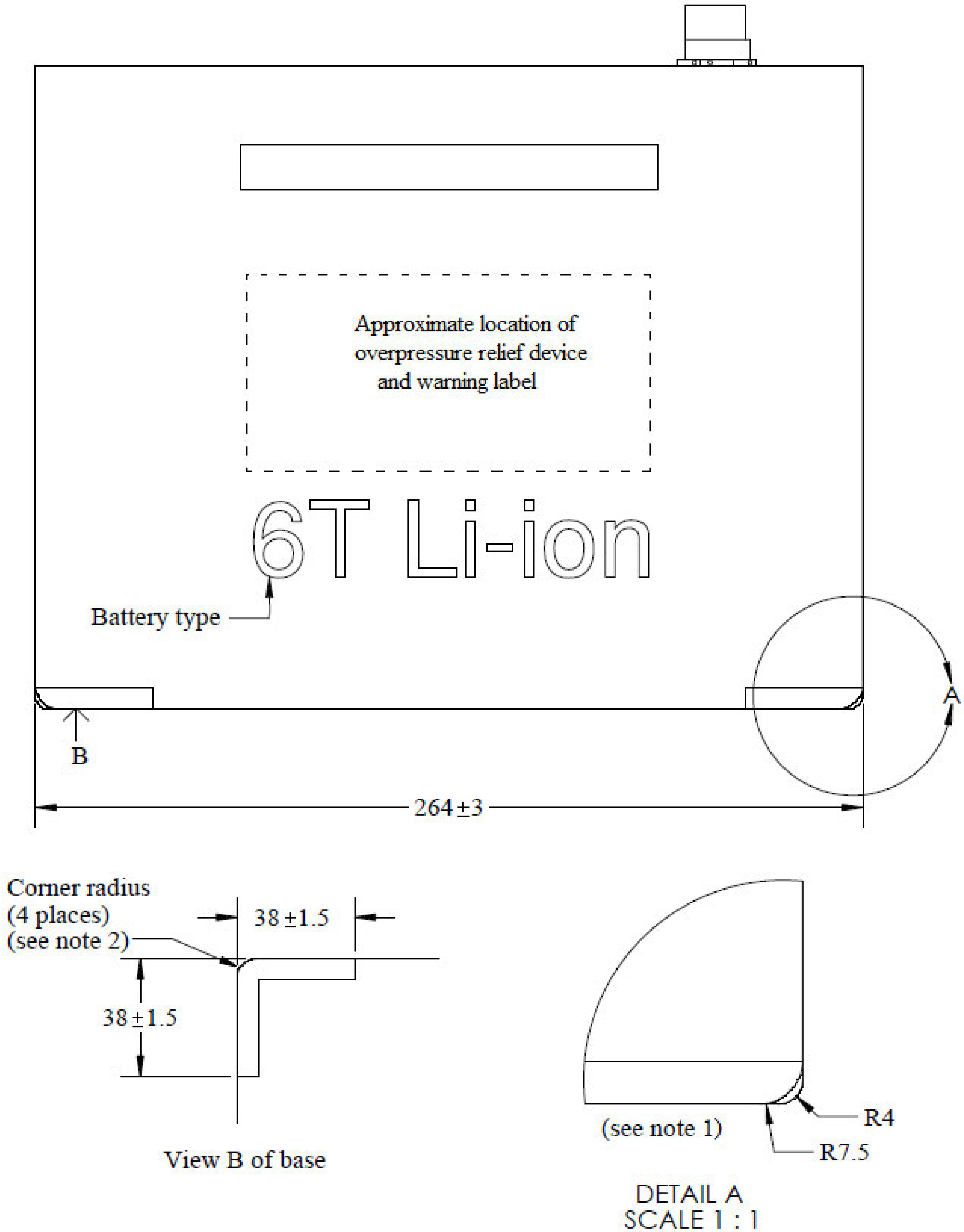
1. Polarity markings shall be embossed on the top side of the battery near each threaded socket with a "-," a "NEG," or an "N" for negative and a "+," a "POS," or a "P" for positive.
2. Chamfer or continuous radius providing equivalent clearance is permitted.

FIGURE 1. Top view battery dimensions.



NOTES:
1. Ribbing and detailing sides of batteries optional.
2. Chamfer or continuous radius providing equivalent clearance is permitted.

FIGURE 2. Front view battery dimensions.



NOTE:
1. Ribbing and detailing on sides of battery is optional.
2. Chamfer or continuous radius providing equivalent clearance is permitted.

FIGURE 3. Side view battery dimensions.

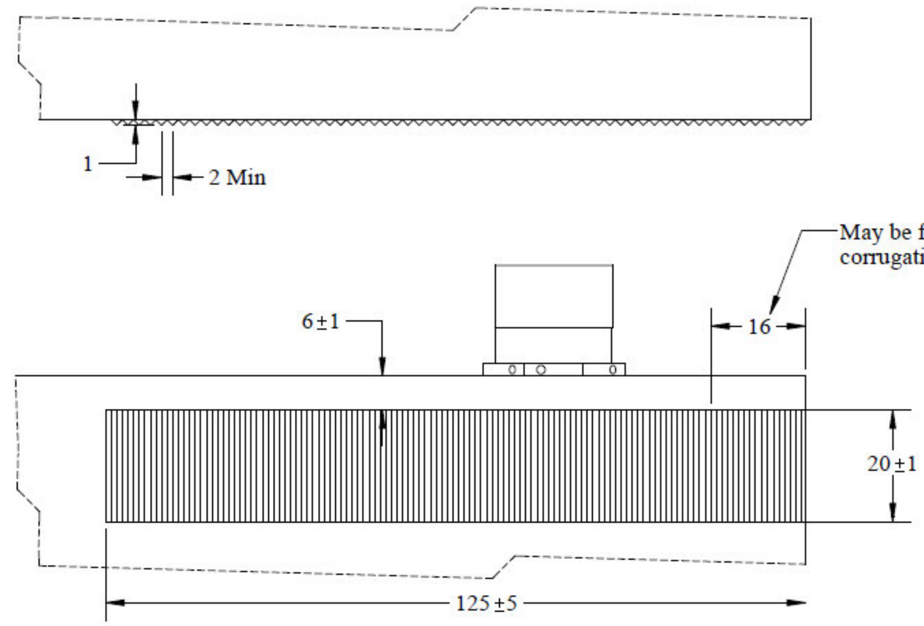


FIGURE 4. Corrugations by positive post.

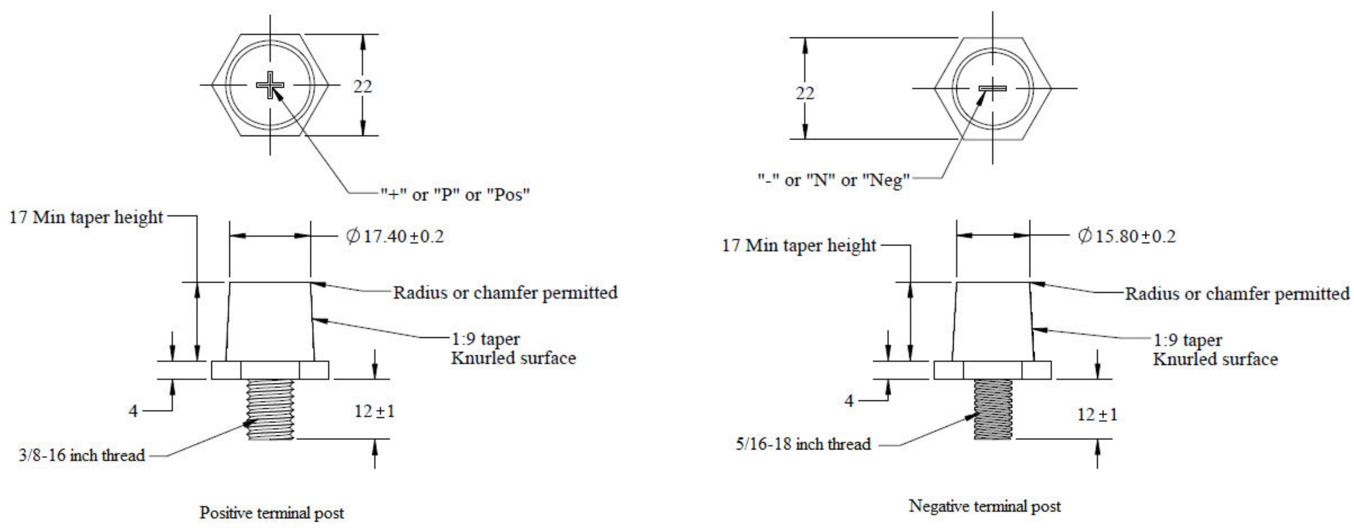


FIGURE 5. Terminal posts.

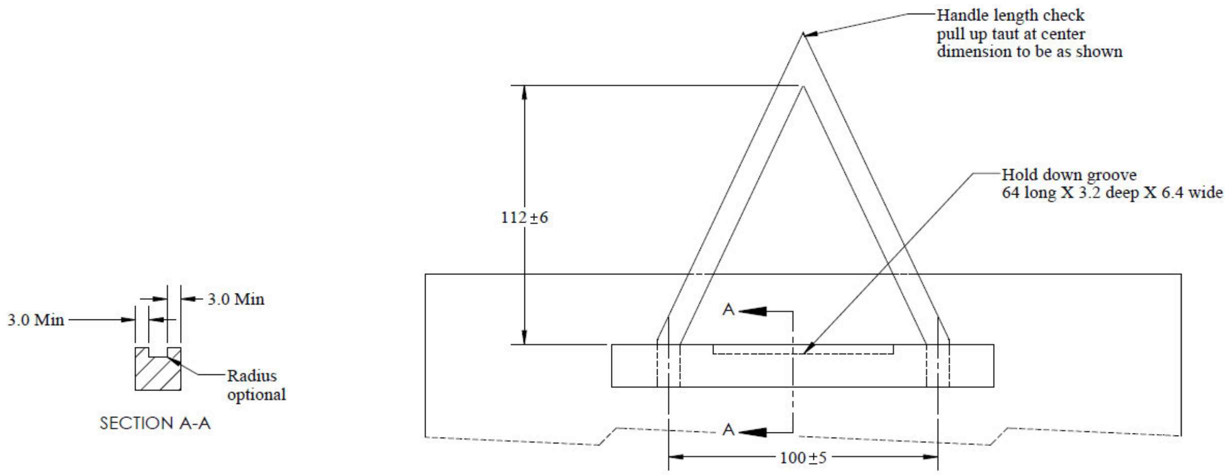


FIGURE 6. Handles.

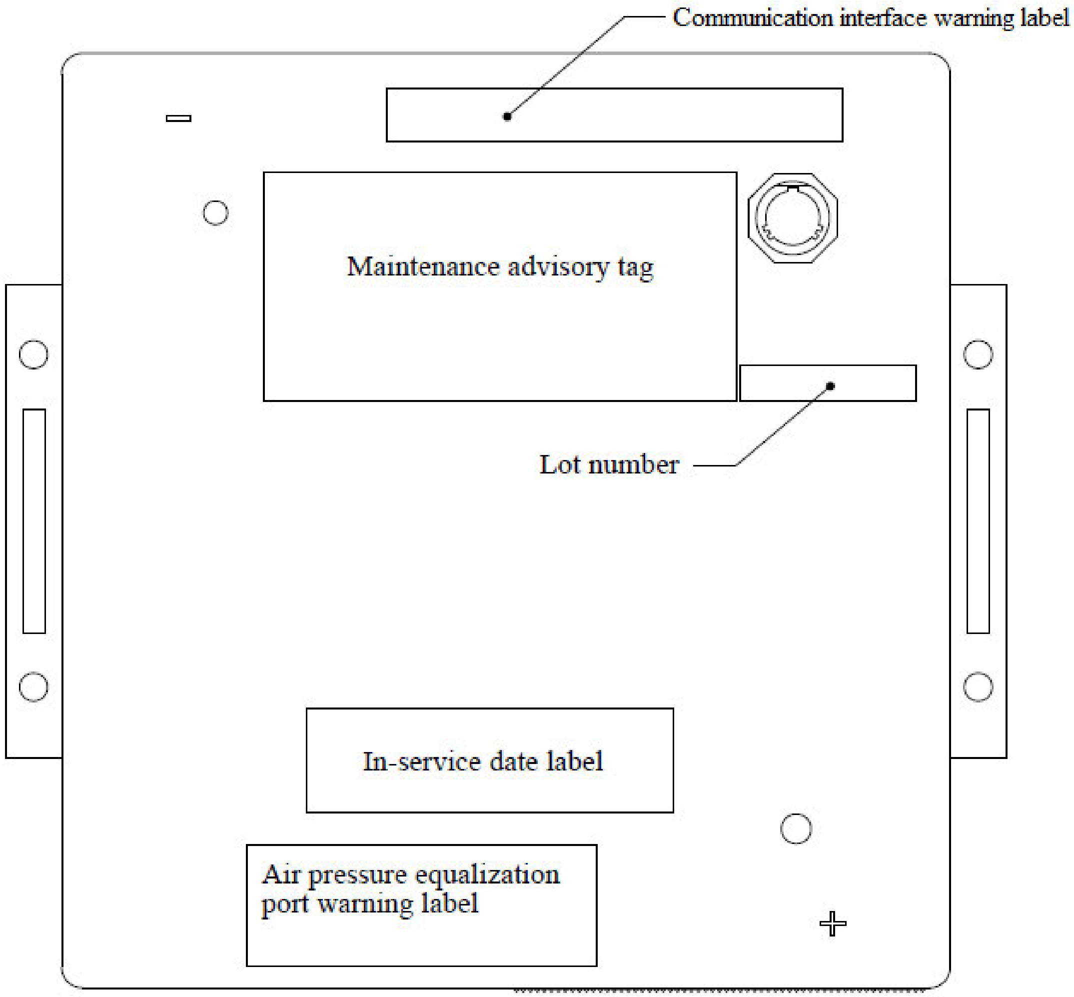
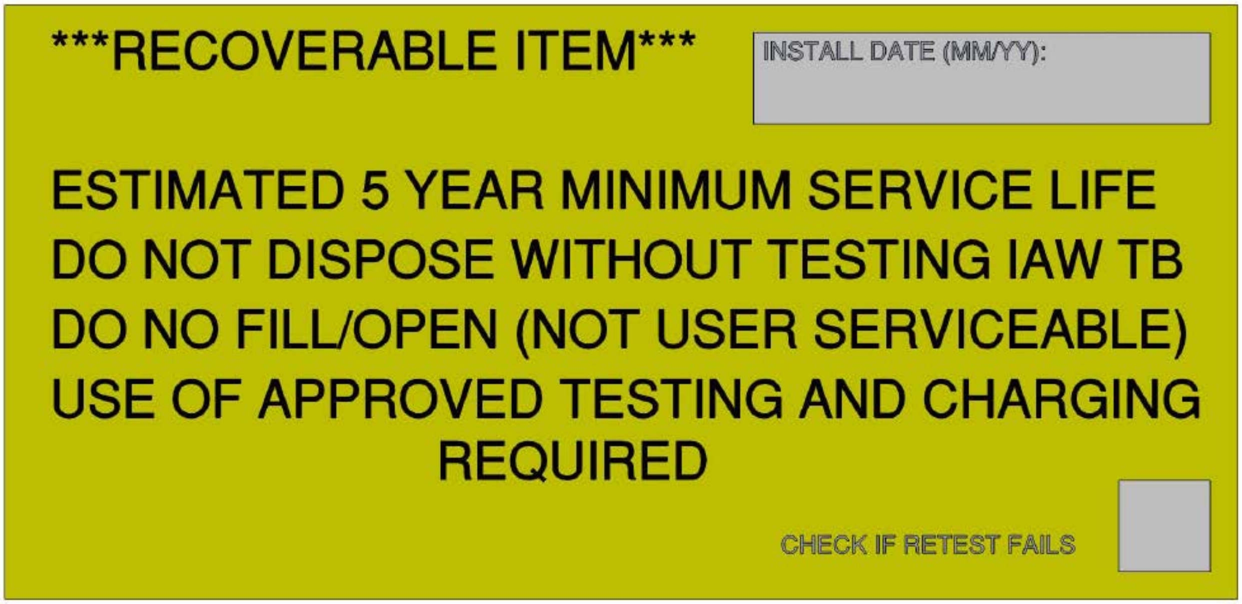


FIGURE 7. Labels required for top of battery.



NOTES:
1. Placement of mandatory statements and boxes, within label, is flexible.

FIGURE 8. Maintenance advisory tag.

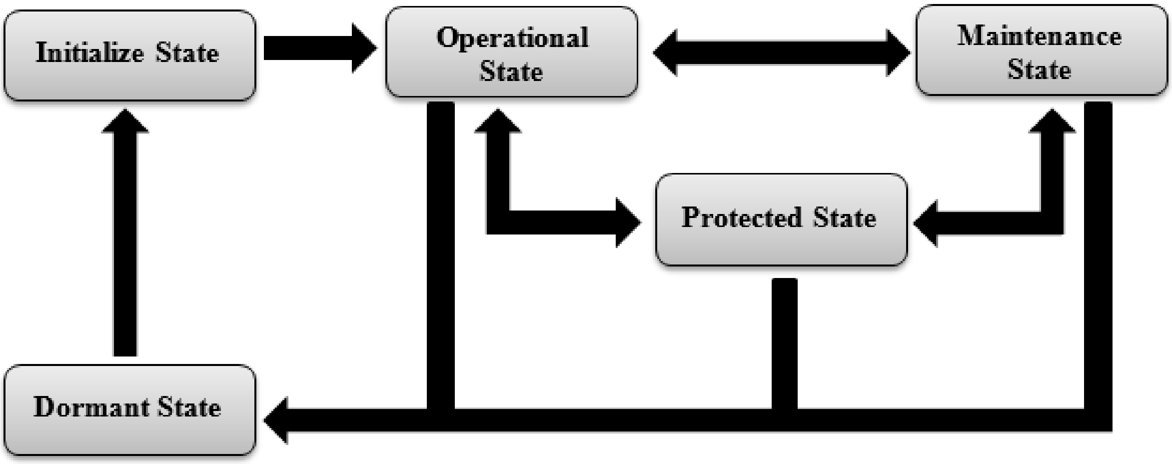


FIGURE 9. Battery state map.

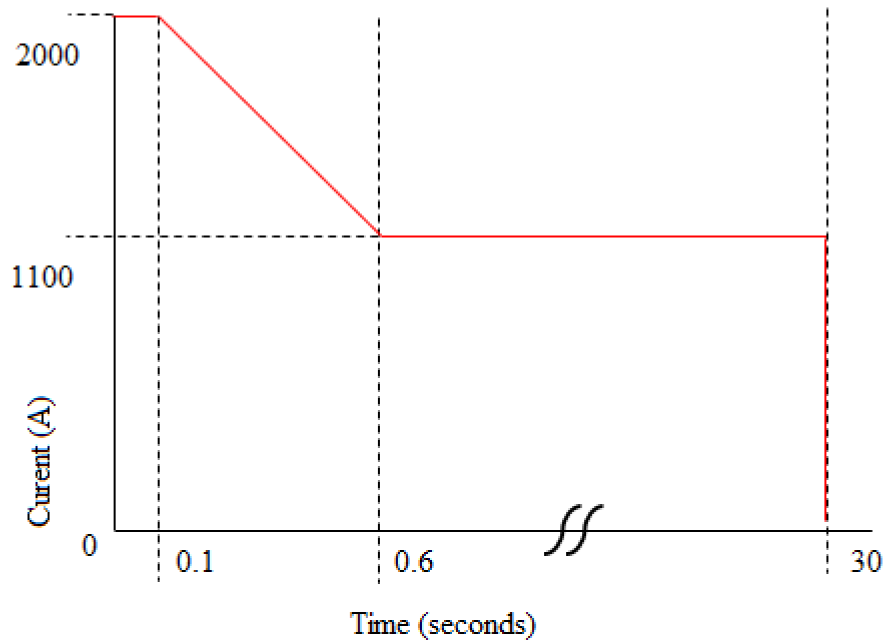
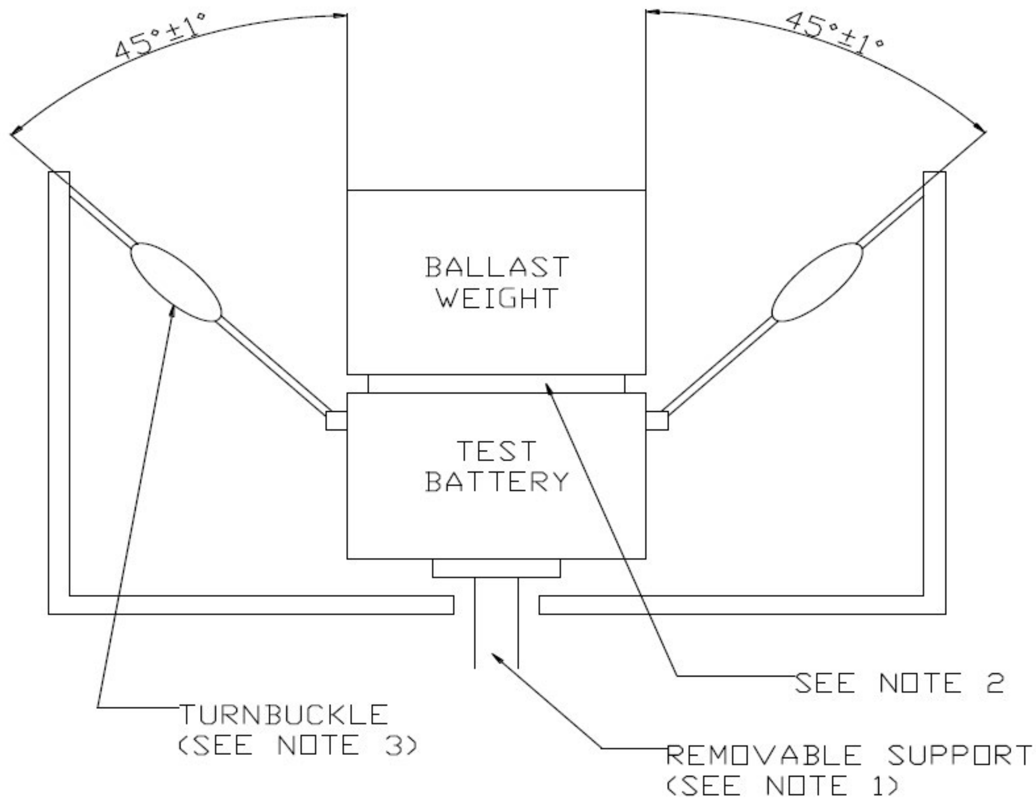


FIGURE 10. Vehicle starting current.



NOTES:

1. Support shall allow gradual and even removal so as to minimize shock and insure even loading of both handles.
2. A lightweight (less than 1 kg) shim may be used between battery and weight to prevent damage to caps, posts or cover.
3. Turnbuckles shall be used to establish 45 ° angles of handles with test weight applied after removal of support. Turn buckles shall include a device to support rope handles over a length of 112 mm during test.

FIGURE 11. Handle test.

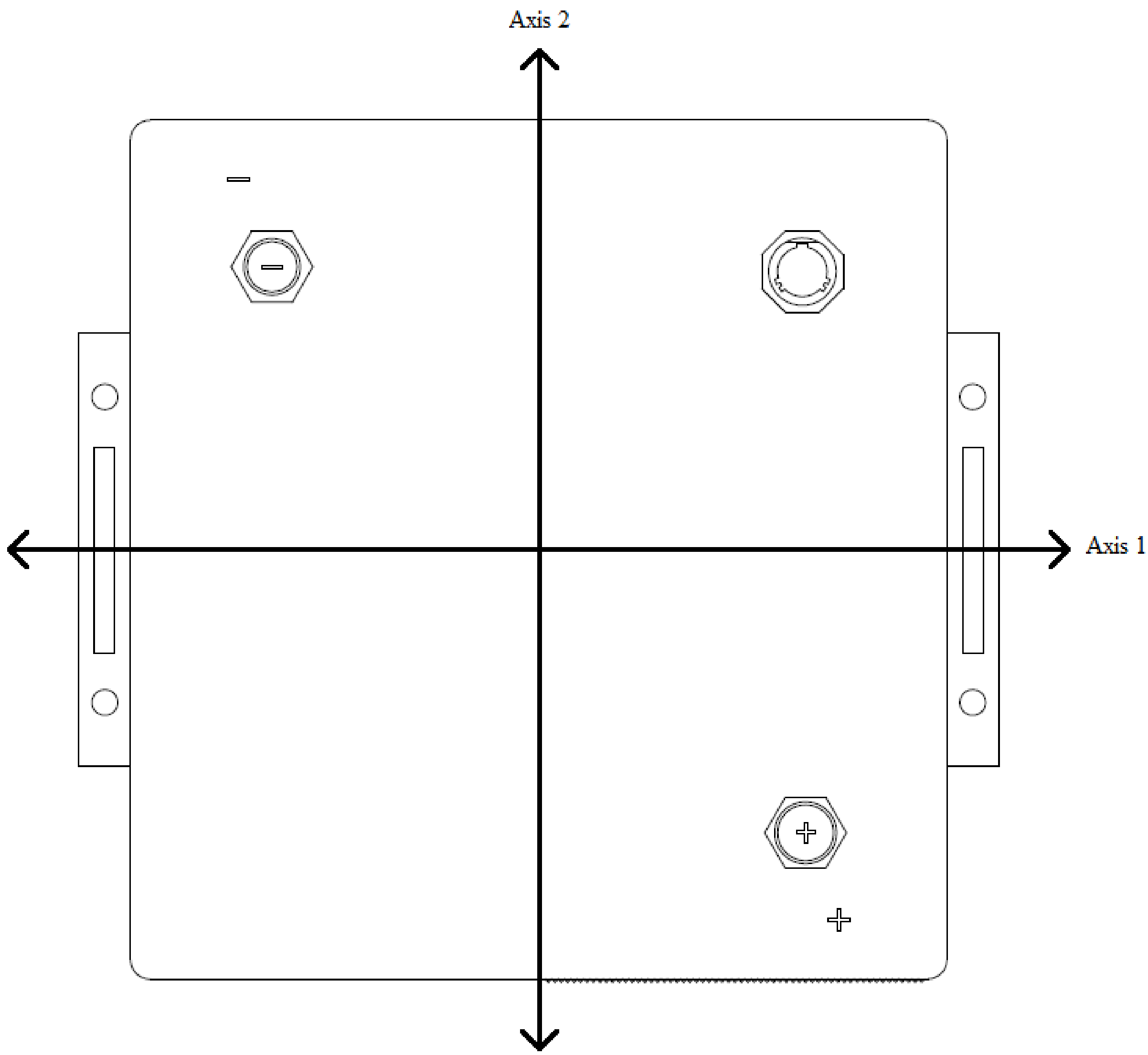
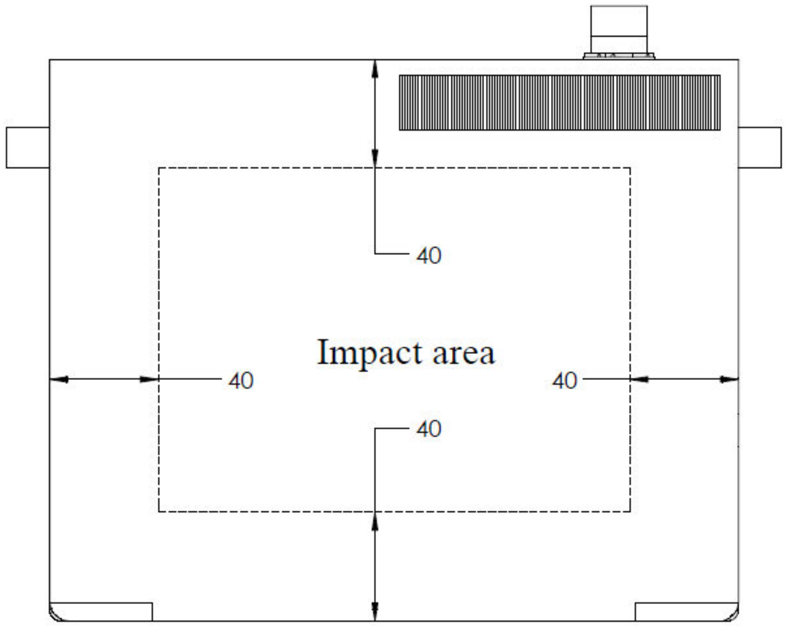
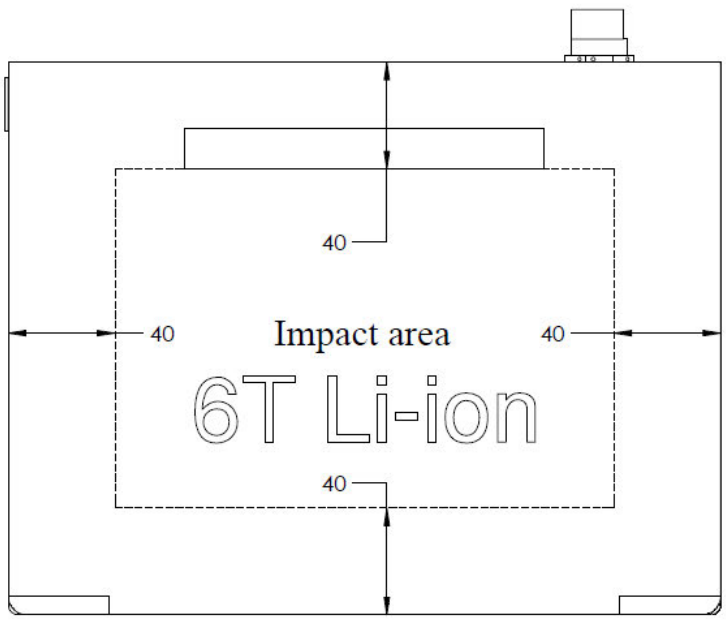


FIGURE 12. Line of impact.



Front view



Side view

FIGURE 13. Battery impact areas.

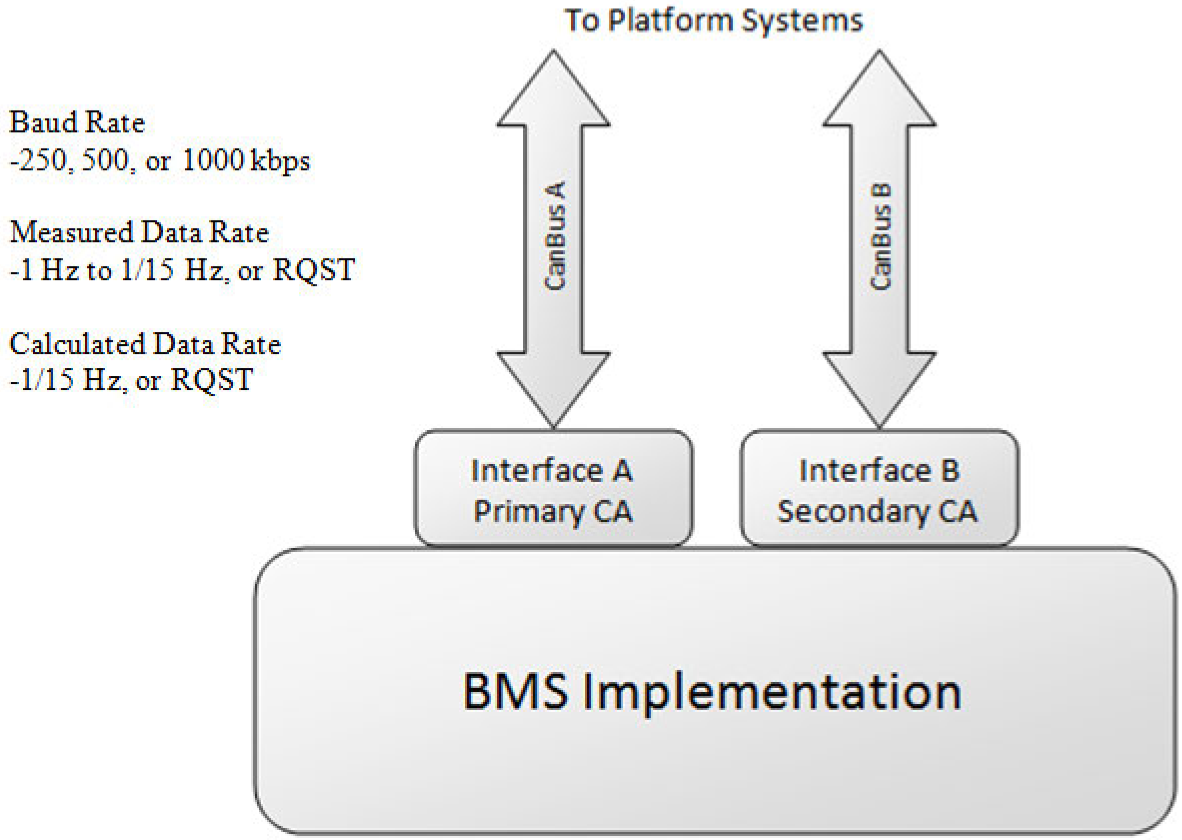


FIGURE 14. BMS SAE J1939 implementation concept.

Battery Interface Control Document and SAE J1939 Messages

A.1 SCOPE

A.1.1 Scope. This appendix is a mandatory part of this specification. This appendix covers the interface and communication requirements of the battery.

A.2 APPLICABLE DOCUMENTS

A.2.1 General. The documents listed in this section are specified Appendix A of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendix A of this specification, whether or not they are listed.

A.2.2 Government documents.

A.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-DTL-38999	-	General Specification for Connectors, Electrical Circular, Miniature, High Density, Quick Disconnect, Environment Resistant, Removable Crimp and Hermetic Solder Contacts

(Copies of this document are available online at http://quicksearch.dla.mil.)

A.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents those cited in the solicitation or contract.

SAE INTERNATIONAL

SAE J1939	-	Serial Control and Communications Heavy Duty Vehicle Network - Top Level Document
SAE J1939/11	-	Physical Layer 250 kbps Twisted Shielded Pair
SAE J1939/14	-	Physical Layer 500 kbps
SAE J1939/21	-	Data Link Layer
SAE J1939/31	-	Network Layer
SAE J1939/71	-	Vehicle Application Layer

SAE J1939/73	-	Application Layer - Diagnostics
SAE J1939/81	-	Network Management

(Copies of these documents are available online at www.sae.org.)

A.3 INTERFACES.

A.3.1 Location. The battery shall have the interfaces depicted in figure 1.

A.3.2 Electrical Interfaces. See 3.3.3.2.

A.3.2.1 Isolation. See 3.3.3.2.1.

A.3.3 Pin definitions.

A.3.3.1 Power. Power (PWR) of the battery communication interface (J1) shall be capable of providing 24 V DC nominal with a maximum continuous current of 100 mA in all battery states (see 3.6.6). Voltage range shall conform to MIL-STD-1275. PWR shall use power (PWR) return of the battery communication interface (J1) as the electrical power return. The battery shall not accept electrical power from an external power source on PWR and PWR return of the battery communication interface (J1).

A.3.3.2 Dormant. Dormant 1 and dormant 2 of the battery communication interface (J1) shall be used to enter or exit the Dormant State (see 3.6.6.1). Current through dormant 1 and dormant 2 shall not exceed 10 mA.

a. Type 1. For a Type 1 battery, the battery shall transition out of the Dormant State when dormant 1 is shorted to COM. An equivalent resistance of 100 ohms or less shall be considered “shorted”. The battery shall transition into the Dormant State when dormant 1 is floating with respect to COM. An equivalent resistance of 1 megaohm or greater shall be considered “floating”. The state of dormant 2 (shorted or floating with respect to COM) shall not be considered in determining action to enter or exit the Dormant State.

b. Type 2 and Type 3. For a Type 2 and Type 3 battery, the battery shall transition out of the Dormant State when dormant 1 and dormant 2 are both shorted to COM. An equivalent resistance of 100 Ohms or less shall be considered “shorted”. The battery shall transition into the Dormant State when dormant 1 or dormant 2 are floating with respect to COM. An equivalent resistance of 1 megaohm or greater shall be considered “floating”.

A.3.3.3 Master power switch. The battery shall use master power switch in and master power switch return configuration pins to determine when to report CAN messages on a regular interval, and when to enable the automated heater function in the Operational State. The battery shall determine the “On” or “Off” state of the vehicle master power switch using the master power switch in and return contacts. Current through the master power switch in and return shall not exceed 10 mA. The master power switch “On” and “Off” states shall be defined as follows:

a. “On” state shall be identified as a sourcing voltage equivalent to the vehicle bus voltage range defined in MIL-STD-1275.

b. “Off” state shall be identified as an open switch, with floating potential between master power switch in and return.

The master power switch in and return may be connected to battery power terminals or vehicle power bus to provide the source voltage for the master power switch “On” and “Off” signals. Alternatively, the master power switch signals may be provided by connecting master power switch in to PWR, and master power switch return to PWR return of the battery communication interface (J1).

A.3.3.3.1 Virtual master power switch. For instances when a vehicle is unable to provide the necessary master power switch signal to the battery communication interface, the battery shall be capable of receiving the virtual master power switch (VMPS) signal as a substitute to provide the same functionality and control over the battery. The virtual master power switch shall be controlled using CAN messages to update the state of the virtual master power switch as either “On” or “Off”. When the battery receives the battery configuration message parameter “Configure VMPS Function” with value of “Enable VMPS Function”, the battery shall ignore master power switch signals on the battery communication interface (J1) and use the value of the “Virtual Master Power Switch Command” to provide the same functionality. When the battery receives the battery configuration message parameter “Configure VMPS Function” with value of “Disable VMPS Function”, the battery shall only use the master power switch discrete signal to the communication interface. The “Configure VMPS Function” use configuration default according to A.5.3. The state of the virtual master power switch shall be defined as follows:

a. The state of the VMPS shall be “On” when the battery receives the battery configuration message parameter “Virtual Master Power Switch Command” with value “VMPS is on”. The battery configuration message shall be sent with this value at a minimum of one time every fifteen seconds.

b. The state of the VMPS shall be “Off” when the battery receives the battery configuration message parameter “Virtual Master Power Switch command” with value “VMPS is off”. If a minimum of 16 seconds has elapsed since the battery received the battery configuration message parameter “Virtual Master Power Switch Command” with a value of “VMPS is on”, the state of the VMPS shall be “Off”.

A.3.3.4 CAN. The battery shall use the appropriate CAN shield, high, and low connections in order to operate on CAN A and CAN B SAE J1939 vehicle networks.

A.3.3.5 Configuration pins 1-2, baud rate. The battery shall use the following configuration pins to determine the CAN communication baud rate, based on the values of configuration pins 1 and 2. The battery shall be able to respond to changes to the configuration pins at a minimum when the battery is in the Initialize State , when the master power switch changes state, when the battery transitions to or from the Maintenance State, or when the battery configuration message is sent parameter “Reset” with value “Soft Reset” or parameter “Restore Defaults” with value “Restore all settings to Factory Defaults” or “Clear all parameter overwrites (except PGN Tx rates), restore defaults”.

00_2	1 Mbps
01	500 kbps
10	250 kbps,
11	250 kbps, CAN limited mode*

The bit order shall have configuration pin 2 as the most significant bit, and configuration pin 1 as the least significant bit.

*In CAN limited mode, all CAN bus address arbitration and initialization procedures according to in SAE J1939, and regular interval message reporting for all CAN messages when the master power switch is “On” shall be disabled. The battery shall be capable of receiving request (RQST) and other CAN messages, and respond with the appropriate CAN messages (i.e. communicate with a diagnostic tool connected to the communication port) on both CAN A and CAN B interfaces. This setting is only recommended for vehicles that will not be connecting batteries to a vehicle CAN bus.

A.3.3.6 Configuration pins 3-6, position identity. The battery shall use the following configuration pins to determine the battery position identity, based on the values of configuration pins three (3) through six (6). The battery shall be able to respond to changes to the configuration pins at a minimum when the battery is in the Initialize State, when the master power switch changes state, when the battery transitions to or from the Maintenance State, or when the battery configuration message is sent parameter “Reset” with value “Soft Reset” or parameter “Restore Defaults” with value “Restore all settings to Factory Defaults” or “Clear all parameter overwrites (except PGN Tx rates), restore defaults”.

$0 – E_{16}$	Positions 0 through 14
F	Position 15 (defined as “Null Position ID”)

The bit order shall have configuration pin 6 as the most significant bit, and configuration pin 3 as the least significant bit.

A.3.3.7 Reset. The reset pin is intended to be used by maintainers, and is not recommended for operation while installed in a vehicle. The battery shall detect when reset has changed state, in all states except the Dormant State, to perform a power cycle of the BMS while maintaining all previous configurations, or power cycle of the BMS while restoring the battery configuration to factory defaults. When using the reset pin to peform a battery reset, the master power switch in and return of the battery communication interface (J1) shall remain in the “On” state. The virtual master power switch shall not be used when using the reset pin to perform a battery reset. The battery shall detect the state of the reset pin, shall count the duration that reset has a value of FALSE to determine action, and perform the action when the state has changed from FALSE (shorted to COM) to TRUE (floating from COM). If reset has been FALSE for less than 3 seconds, the battery shall take no action. If reset has been FALSE for at least 3 seconds, but not more than 15 seconds, the BMS shall power cycle while maintaining all previous configurations. If reset has been FALSE for 15 seconds or greater, the battery shall power cycle while restoring the battery configuration to factory defaults. The battery shall timeout and power cycle while restoring the battery configuration to factory defaults if reset has been FALSE for 30 seconds or more.

A.3.3.8 Common. Dormant, configuration pins and reset shall use the common pin (COM) as a reference node. Configuration pins shorted to COM shall have the value of "0" or "FALSE", and floating (not shorted) to COM shall have a value of "1", or "TRUE".

A.4 CAN BUS

A.4.1 CAN bus physical characteristics. The battery CAN bus interfaces shall not have significant termination resistance. Termination resistance required for CAN communication shall be provided externally. The battery shall have one CAN bus address common for both the primary and secondary interface. The BMS shall have one bus controller implemented for each of the CAN bus interfaces. See figure 14 for concept diagram of CAN bus implementation.

A.4.2 CAN message response. The battery shall immediately respond to messages (i.e. RQST message) received from CAN A or CAN B on the bus from which the message was received. Regular interval transmission messages, except the Heartbeat Message, and messages triggered by an event shall be transmitted on the primary CAN interface only. If the master power switch is "Off", and no communication activity has occurred on the CAN bus for more than 15 minutes, the battery shall be capable of responding to the request or other messages within 5 seconds of start of communication activity on the CAN bus. The battery shall not be required to process or respond to request or other messages intended for the battery sent before completion of this 5 second period.

A.4.3 Primary CAN interface selection. The battery shall use the "Set Primary CAN Interface" parameter of the battery configuration message to select the primary CAN interface (CAN A or CAN B). See section A.5.3 for configuration default.

A.4.4 Heartbeat CAN interface selection. The heartbeat message shall use the "Heartbeat CAN Interface" parameter of the battery configuration message to select the CAN Interface which the message shall be transmitted. See section A.5.3 for configuration default.

A.4.5 Bit timing. The CAN bus physical bit timings, as specified in ISO 11898-1, ISO 11898-2, ISO 11898-3, ISO 11898-4, and ISO 11898-5 , for the BMS systems are as follows:

a. The sample point shall be as close to, but not later than, 87.5 percent of the bit time.

b. The synchronization jump width shall be 1-time quanta.

c. The sampling mode shall be single sampling.

d. The synchronization shall be 'recessive to dominant' edges only.

A.4.6 BMS J1939 implementation. The BMS shall be Compliant to the following SAE J1939 standards:

a. SAE J1939

b. SAE J1939/21

c. SAE J1939/31

d. SAE J1939/71

e. SAE J1939/73

f. SAE J1939/81

A.4.7 NAME of controller application. The battery shall have a NAME in accordance with SAE J1939-81. The NAME shall be communicated on the CAN bus when a request Message is received for address claimed, and as required according to SAE J1939. The battery NAME shall be configurable in the Maintenance State using the SAE J1939 NAME management message. The battery NAME shall revert to the original NAME based on defaults when "Restore Defaults" in the battery configuration message has a value of "Restore all settings to Factory defaults" or "Clear all parameter overwrites (except PGN Tx Rates), restore defaults". The function instance field of the battery NAME, shall be equal to the position identity, unless configured otherwise in the Maintenance State. For example, battery with position identity 0 shall have the function instance field of set to 0.

A.4.8 Preferred source address. The battery, by default, shall use the preferred source address based on the battery position identity according to table III.

a. The arbitrary address capability shall be enabled or disabled using the NAME management message, according to SAE J1939-81, by using the Commanded Arbitrary Address Capable parameter in the Maintenance State. The NAME arbitrary address capable field shall be updated accordingly.

b. The battery shall use the value of the commanded address message as the preferred source address when configured in the Maintenance State and stored in memory. When the battery preferred address has been configured with a commanded address message, arbitrary address capability shall be disabled, and the NAME arbitrary address capable field shall be updated accordingly.

c. The battery preferred source address and arbitrary address capability shall be restored to configuration defaults (see A.5.3) when the battery configuration message "Restore Defaults" parameter has a value of "Restore all settings to Factory defaults" or "Clear all parameter overwrites (except PGN Tx Rates), restore defaults", or when the reset pin method (A.3.3.7) is used. The NAME message shall be updated accordingly.

A.4.9 Arbitrary address capability. When battery address arbitration capability is enabled, the battery shall follow address arbitration procedures according to SAE J1939. When the battery is unable to claim its preferred source address due to address contention, the battery shall not attempt to claim any source address listed in table III. The battery shall first attempt to claim the source address that is one less than the lowest value source address listed in table III. Further attempts shall use a source address with a value of one less than the previous attempt, until attempting to claim address 128. If battery is unable to claim address 128, the battery shall fail to claim a source address and peform cannot claim address procedures according to SAE J1939.

A.5 PROGRAM, CONFIGURATION, AND DATA MEMORY

A.5.1 Firmware diagnostics. Firmware diagnostic programs shall be stored in non-volatile memory. Programs and data stored in non-volatile memory shall include system level or maintenance software, firmware upgrade procedures, configuration identifier, data download, diagnostic filtering algorithms, DTC status, proprietary PGN and SPN functionality, and data transmission rates.

A.5.2 Firmware update. Firmware update shall be performed over the CAN bus. Firmware update method over CAN bus shall follow the SAE J1939 guidelines for memory access and reflashing (see J1939/73 for more information), and the method shall be destination specific. The method shall be performed using standard J1939 messaging for memory update operations including the Transport Protocol and the following messages as appropriate: Stop Start Broadcast (DM13), Memory Access Request (DM14), Memory Access Response (DM15), Binary Data Transfer (DM16), Boot Load Data (DM17), and Data Security (DM18). The battery shall not require removal from the vehicle CAN bus to perform firmware update. The firmware update method shall not impair other controller applications on the vehicle CAN bus. Firmware transfer and installation to completion shall not exceed 15 minutes. Firmware updates shall be provided as binary files that may be executed using software provided for a field-service Maintenance Support Device (laptop computer).

A.5.2.1 Embedded reprogramming. Military platforms may require firmware updates for systems to be performed using an embedded information system installed in the platform. In this case, the platform’s embedded information system shall perform the firmware update using a series of CAN messages according to the battery manufacturer’s firmware update procedure, and the firmware update binary files provided by the battery manufacturer. The Start Broadcast (DM13) message shall be used to prevent the battery from sending routine CAN messages on the CAN bus during firmware reprogramming of platform systems. The battery shall respond to “Current Data Link” and “J1939 Network #1” fields of the Start Broadcast (DM13) message in accordance with to SAE J1939. As an alternative to SAE J1939 defined usage of the DM13 message, the platform embedded information system may send the DM13 message with “Current Data Link” or “J1939 Network #1” fields set to “Stop Broadcast” to the global address a minimum rate of once every 5 seconds. In this case, the Battery shall resume normal operations when the DM13 message is not received for 6 seconds or more, or when the DM13 message is received with “Current Data Link” or “J1939 Network #1” fields set to “Start Broadcast.” When a DM13 message is received on either CAN A or CAN B interfaces, the requested action shall be applied to both CAN A and CAN B interfaces in accordance with SAE J1939.

A.5.3 Configuration defaults. The battery shall use the following configuration values by default, when using the "Restore Defaults" parameter:

a. Preferred Source Address: Based on position identity according to table III

b. NAME: In accordance with SAE J1939, function instance equal to position identity

c. Battery Battle Override: Battery Battle Override disabled

d. Heater Function: Enable Automated Heater Function

e. Command Contactor(s): Automated Contactor(s) Operation

f. Baud Rate: Based on configuration pin values

g. Position Identity: Based on configuration pin values

h. Arbitrary Address Capability: Enabled

i. Primary CAN Interface: CAN A

j. Heartbeat CAN Interface: Primary CAN Interface Only

k. Heartbeat Tx Rate: On Request

l. Configure VMPS Function: Disable VMPS Function

m. SOC Reserve Limit: 0% SOC

A.5.4 Configuration overwrite. The battery shall accept values for baud rate and position identity using the "Overwrite Baud Rate" and "Overwrite Position Identity" parameters of the battery configuration message, which shall be used for configuration in place of the configuration pin values. The function instance field of the SAE J1939 NAME and the preferred source address (see table III) shall be updated accordingly when the position identity parameter is overwritten. Configuration overwrites shall be retained in all battery states, except when the baud rate and position identity are restored to configuration defaults (see A.5.3). The battery shall restore baud rate and position identity to configuration defaults when the following occur:

a. Battery configuration message "Restore Defaults" parameter has a value of "Clear all parameter overwrites (except PGN Tx Rates), restore defaults"

b. Battery configuration message "Restore Defaults" parameters has a value of "Restore all settings to Factory defaults"

c. The reset pin method (see A.3.3.7) is used

A.5.5 <u>CAN message transmission rates</u>. All battery SAE J1939 Proprietary B messages (except the heartbeat message) and other messages with a regular transmission interval shall have transmission rates be configurable using the battery configuration message "Configure PGN" and "PGN Tx Rate" parameters. Unless specified otherwise, messages with battery level measurement data shall transmit by default at a rate of one time every second, and messages with calculated data or status information shall transmit by default at a rate of 1 time every 15 seconds. Messages containing other data types shall be transmitted on request by default. CAN message transmission rate overwrites shall be retained in all battery states, unless restored to their default CAN message transmission rates. The battery shall restore CAN messages to their default transmission rate when the following occur:

a. Battery configuration message "Configure PGN" parameter has a value equal to a particular message's assigned PGN, and "PGN Tx Rate" has a value of "Reset PGN to its default Tx Rate".

b. Battery configuration message "Restore Defaults" parameter has a value of "Clear all PGN Tx Rate overwrites, restore defaults". The hearbeat message trasmission rate shall not be restored with this parameter and value.

c. Battery configuration message "Restore Defaults" parameters has a value of "Restore all settings to Factory defaults"

d. The reset pin method (see A.3.3.7) is used

A.5.5.1 <u>Heartbeat message transmission rate</u>. The heartbeat message (PGN 65280) shall have its transmission rate be configurable using the battery configuration message "Heartbeat Tx Rate" parameter. Heartbeat Message transmission rate overwrite shall be retained in all battery states, except when it is restored to its configuration default (see A.5.3) when the following occur:

a. Battery configuration message "Restore Defaults" has a value of "Clear all parameter overwrites (except PGN Tx Rates), restore defaults".

b. Battery configuration message "Restore Defaults" parameters has a value of "Restore all settings to Factory defaults"

c. The reset pin method (see A.3.3.7) is used

A.5.6 <u>SOC Reserve Limit</u>. The battery shall have a configurable SOC reserve limit. This limit shall be used to transition the battery to the Protected State when the battery state-of-charge falls below this limit while the battery is discharging or has no load state, in order to limit battery operation below this limit. This limit shall only be used when the battery is in the Operational State. When the only cause for the battery being in the Protected State is that the battery state-of-charge has fallen below the SOC reseve limit, and the battery protection is reset according to methods specified in 3.6.6.5, the battery shall return to the Operational State for a minimum of 5 minutes. The battery shall not return to the protected state while the battery is charging, unless charging ceases and the battery state-of-charge is below the SOC reserve limit. This limit shall be temporarily suspended when the battery battle-override command is received as specified in 3.3.6. When the battery is in the Protected State with a battery state-of-charge below the SOC reserve limit, the battery shall be capable of entering the Maintenance State. The SOC reserve limit shall be configured in the Maintenance State. When the SOC Reserve Limit is configured to 0%, this feature shall be deactivated. See section A.5.3 for configuration.

A.5.7 Long term fault data storage (non-volatile). Long term data recording of battery fault data shall be stored in non-volatile memory. Long term fault data storage shall support recording critical fault data to support a mission of 96 hours.

A.5.8 Short term fault data storage (volatile). Short term fault data shall be stored in volatile memory. The battery shall provide diagnostic filtering of all parameters. The battery shall provide diagnostic filtering of faults at a periodic rate and store the Diagnostic Trouble Code (DTC) fault and time stamp in non-volatile memory as required. The battery shall provide a first-in last-out data stack for each DTC Status. No more than one state change per DTC shall be transmitted per second, except for critical or safety DTCs.

A.5.9 BMS CAN J1939 application layer. The battery shall use CAN (J1939) industry standard to include BMS embedded diagnostics with real-time Diagnostic Trouble Code (DTC) reporting and diagnostic filtering. The diagnostic filtering shall provide a SAE J1939 industry standard fault reporting.

A.5.10 Diagnostics. The battery shall provide diagnostic capability for fault and failure detection from built-in tests. BIT results shall be provided in messages over the CAN bus, and faults and failures shall be communicated in the form of Diagnostic Trouble Codes (DTCs). Diagnostic capabilities shall follow SAE J1939/73 for Diagnostic Trouble Codes (DTCs) information and management.

A.6 MESSAGES

A.6.1 Messages. This section specifies the messages that each J1939 controller application interface shall send and receive as part of the SAE J1939 protocol, in addition to the messages which are battery specific.

A.6.2 SAE J1939 messages. The following are messages supported as part of the SAE J1939 Network Management protocol and shall be the minimum, but not limited to, set of messages used by the battery to facilitate integration onto the target platform's SAE J1939 network.

a. NAME Management (NM) message

b. Request (RQST)

c. Address Claimed (AC) (contains NAME of a Controller Application)

d. Acknowledgement Message (ACKM)

e. Commanded Address (CA)

f. Stop Start Broadcast (DM13)

g. Memory Access Request (DM14)

h. Memory Access Response (DM15)

i. Binary Data Transfer (DM16)

j. Boot Load Data (DM17)

k. Transport Protocol – Connection Management (TP.CM)

l. Connection Mode Request to Send (TP.CM_RTS)

m. Connection Mode Clear to Send (TP.CM_CTS)

n. Connection Management End of Message Acknowledgment (TP.CM_EndOfMsgACK)

o. Connection Abort (TP_Conn_Abort)

p. Transport Protocol – Data Transfer (TP.DT)

q. Vehicle Electrical Power #5 (VEP5)

r. Battery Temperature (BT1)

A.6.3 Battery specific messages. The following data (SAE J1939 PDU2 Format – Proprietary B) shall be made available by the battery when in the Operational State:

a. Battery Configuration Message(s)

b. Heartbeat Message

c. Battery Measurement Message(s)

d. Battery Calculations Message(s)

e. Battery Regulation Information Message(s)

f. Battery Power Capability Prediction Message(s)

g. Battery Status Information Messages (s)

h. Battery Built-in Test (PBIT, CBIT) Results Message(s)

i. Cell Voltage Message(s)

j. Battery Equalization Message(s)

k. Battery Manufacturer Specific Message(s)

A.6.4 BMS parameter group number (PGN) and suspect parameter number (SPN) reservation and prohibition. Proprietary messages defined by the battery manufacturer shall not use a Parameter Group Number (PGN) reserved for Government definition or PGNs that are prohibited in this specification. Suspect Parameter Numbers for manufacturer specific parameters shall not use a Suspect Parameter Number reserved for Government definition.

a. PGN 61184 Proprietary A, Data Page 0, Control Bytes 0 through 63 reserved for USG definition.

b. PGN 65280 – 65343 Proprietary B, Data Page 0 reserved for USG definition.

c. Proprietary B, Data Page 1 shall not be used for messaging on the CAN bus.

d. Proprietary A, Data Page 1 is open for manufacturer definition and use.

e. SPN 516096 – 518144 are reserved for USG definition.

A.6.5 Proprietary A J1939 PGN Message Definition and Structure. The following message (SAE J1939 PDU1 Format – Proprietary A) shall be used to enable battery battle override, enable/disable the heaters and contactors, enter/exit the Maintenance State, set configurable parameters, or perform other configuration functions within the battery. The first byte of the message shall be the Control byte, with values 0 through 63 reserved for Government definition. The battery shall provide an Acknowledgement message each time a battery configuration message is received. The range of values for parameters used in Proprietary A/A2 messages shall conform to J1939-71 (see sections Parameter Ranges and Assignment of Ranges to New Parameters) when applicable.

NOTE: In the following message(s), bit significance shall be in the following order: bit closest to position (x.1) is least significant, and bit closest to position (x.8) is most significant.

PGN 61184

Description: Battery Configuration

Transmission Repetition Rate: On Request
Data Length: 8,
Extended Data Page: 0
Data Page: 0
PDU Format: 239 (0xEF)
PDU Specific: DA
Default Priority: 6
Parameter Group Number: 61184
Data Field:

Control Byte = 0

Position	Length	Parameter Name (SPN)
1.1-1.8	8 bits	Control Byte
2.1-2.2	2 bits	Battery Battle Override
2.3-2.4	2 bits	Heater Function
2.5-2.6	2 bits	Command Contactor(s)
2.7-2.8	2 bits	Primary CAN Interface
3.1-3.2	2 bits	Reset
3.3-3.4	2 bits	Maintenance State
3.5-3.6	2 bits	Virtual Master Power Switch Command

Control Byte = 1

Position	Length	Parameter Name (SPN)	Resolution	Offset
1.1-1.8	8 bits	Control Byte		
2.1-2.2	2 bits	Restore Defaults		
2.3-2.4	2 bits	Heartbeat CAN Interface		
2.5-2.8	4 bits	Heartbeat Tx Rate		
3.1-3.2	2 bits	Overwrite Baud Rate		
3.3-3.6	4 bits	Overwrite Position ID		
3.7-3.8	2 bits	Configure VMPS Function		
4.1-6.8	24 bits	Configure PGN		
7.1-7.5	5 bits	PGN Tx Rate		
8.1-8.8	8 bits	SOC Reserve Limit	0.5%/bit	0%

J1939 SPN Message Definitions

SPN (516096) Control Byte
Supporting Information: Control byte associated with the battery configuration message.

SPN (516097) Battery Battle Override*:

00_2	Disable Battle Override
01	Enable Battle Override
10	Reserved
11	NA

*Configuration parameter can be set outside of Maintenance State.

SPN (516098) Heater Function*:

00_2	Disable Automated Heater Function
01	Enable Automated Heater Function
10	Reserved
11	NA

*Configuration parameter can be set outside of Maintenance State.

SPN (516099) Command Contactor(s)*:

00_2	Open Contactor(s)
01	Automated Contactor Operation
10	Force Close Contactor(s)**
11	NA

*Configuration parameter can be set outside of Maintenance State.
** Ability to force close the contactor (s) shall only be allowable in the Maintenance State. Battery shall provide negative acknowledgement to "Force Close Contactor(s)" if battery is not in the Maintenance State.

SPN (516100) Primary CAN Interface*:

00_2	CAN B Primary Interface
01	CAN A Primary Interface
10	Reserved
11	NA

*Configuration parameter can be set outside of Maintenance State.

SPN (516101) Reset*:

00_2	Hard Reset**
01	Soft Reset***
10	Reset Protection
11	NA

*Configuration parameter can be set outside of Maintenance State.
**Shall include power cycling the battery (BMS) hardware
***Battery Manufacturer to define. Not to include power cycling of the battery (BMS).

SPN (516102) Maintenance State*:

00_2	Exit Maintenance State
01	Enter Maintenance State
10	Reserved
11	NA

*Configuration parameter can be set outside of Maintenance State.

SPN (516103) Virtual Master Power Switch Command

00_2	VMPS is off
01	VMPS is on
10	Reserved
11	NA

*Configuration parameter can be set outside of Maintenance State.

SPN (516104) Restore Defaults:

00_2	Restore all settings to Factory defaults
01	Clear all parameter overwrites (except PGN Tx Rates), restore defaults
10	Clear all PGN Tx Rate overwrites, restore defaults*
11	NA

*This parameter shall not be used to modify the Heartbeat Tx Rate parameter.

SPN (516105) Heartbeat CAN Interface:

00_2	Primary and Secondary CAN Interface
01	Primary CAN Interface Only
10	Reserved
11	NA

SPN (516106) Heartbeat Tx Rate:

0_{16}	On Request Only
1	100 milliseconds
2	500 milliseconds
3	1 second
4	5 seconds
5	10 seconds
6	15 seconds
7 – E	Reserved
F	NA

SPN (516107) Overwrite Baud Rate:

00_2	1 Mbps
01	500 Kbps
10	250 Kbps
11	NA

SPN (516108) Overwrite Position ID:

$0 – E_{16}$	Positions 0 through 14
F	NA

SPN (516109) Configure VMPS Function

00_2	Disable VMPS Function
01	Enable VMPS Function
10	Reserved
11	NA

SPN (516110) Configure PGN:
Supporting Information: See SAE J1939-21 section Parameter Group Number (PGN) for definition.

SPN (516111) PGN Tx Rate:

00_{16}	On Request only
01-0F	1, 2, 3 … 15 seconds
10-1D	Reserved
1E	Reset PGN to its default Tx Rate
1F	NA

*This parameter shall not be used to change the Tx rate of the Heartbeat Message. Battery shall provide negative acknowledgement if the "Configure PGN" values is equal to the Heartbeat Message.

SPN (516112) State of Charge (SOC) Reserve Limit
Supporting Information: The State of Charge (SOC) Reserve Limit shall be used to prevent battery from full discharging in the intended application

00 – C8	0% to 100% SOC limit
C9-FE	Reserved
FF	NA

A.6.6 Proprietary B J1939 PGN message definition and structure. The battery shall provide the following Proprietary B, Data Page 0 messages as specified. The range of values for parameters used in Proprietary B PGNs shall conform to J1939-71 (see sections Parameter Ranges and Assignment of Ranges to New Parameters) when applicable.

NOTE: In the following messages, bit significance shall be in the following order: bit closest to position (x.1) is least significant, and bit closest to position (x.8) is most significant.

PGN 65280

Description: Heartbeat
Transmission Repetition Rate: 100 ms to 15000 ms, On Request (On Request by default)
Data Length: 8
Extended Data Page: 0
Data Page: 0
PDU Format: 255 (0xFF)
PDU Specific: 00 (0x00)
Default Priority: 3
Parameter Group Number: 65280
Data Field:

Position	Length	Parameter Name (SPN)
2.1-2.2	2 bits	Primary CAN Interface
2.3-2.4	2 bits	Heartbeat CAN Interface
2.5-2.8	4 bits	Heartbeat Tx Rate
3.1-3.2	2 bits	Battery Status
3.3-3.4	2 bits	CAN A Status
3.5-3.6	2 bits	CAN B Status

J1939 SPN Message Definitions

SPN (516140) Primary CAN Interface:

00_2	CAN B Primary Interface
01	CAN A Primary Interface
10	Reserved
11	NA

SPN (516141) Heartbeat CAN Interface:

00_2	Primary and Secondary CAN Interface
01	Primary CAN Interface Only
10	Reserved
11	NA

SPN (516142) Heartbeat Tx Rate:

0_{16}	On Request Only
1	100 milliseconds
2	500 milliseconds
3	1 second
4	5 seconds
5	10 seconds
6	15 seconds
7 – E	Reserved
F	NA

SPN (516143) Battery Status

00_2	Battery has normal function
01	Battery has a fault
10	Reserved
11	NA

SPN (516144) CAN A Status

00_2	CAN A is not operational
01	CAN A is operational
10	Reserved
11	NA

SPN (516145) CAN B Status

00_2	CAN B is not operational
01	CAN B is operational
10	Reserved
11	NA

PGN 65281

Description: Battery Measurements 1
Transmission Repetition Rate: 1000 ms to 15000 ms, On Request (1000 ms by default)

Data Length: 8
Extended Data Page: 0
Data Page: 0
PDU Format: 255 (0xFF)
PDU Specific: 01 (0x01)
Default Priority: 5
Parameter Group Number: 65281
Data Field:

Position	Length	Parameter Name (SPN)	Resolution	Offset
2.1-3.8	16 bit	Battery Voltage	0.05V/bit	0
4.1-5.8	16 bit	Battery Current	0.05A/bit	-1600
6.1-6.8	8 bit	Battery Internal Temperature (C)	1°C/bit	-55 °C
7.1-8.1	9 bit	Battery Internal Temperature (F)	1°F/bit	-67 °F

J1939 SPN Message Definitions

SPN (516146) Battery Voltage
Supporting Information: The voltage across the battery's power terminals.

SPN (516147) Battery Current
Supporting Information: The net battery charge current (positive) to or discharge current (negative) from the battery's power terminals.

SPN (516148) Internal Battery Temperature (C)
Supporting Information: The internal temperature of the battery, referenced in Celsius.

SPN (516149) Internal Battery Temperature (F)
Supporting Information: The internal temperature of the battery, referenced in Fahrenheit.

PGN 65282

Description: Battery Calculations 1
Transmission Repetition Rate: 15000 ms, On Request (15000 ms by default)
Data Length: 8
Extended Data Page: 0
Data Page: 0
PDU Format: 255 (0xFF)
PDU Specific: 2 (0x02)
Default Priority: 5
Parameter Group Number: 65282
Data Field:

Position	Length	Parameter Name (SPN)	Resolution	Offset
2.1-2.8	8 bit	Battery State of Charge	0.5%/bit	0%
3.1-3.8	8 bit	Battery State of Health	0.5%/bit	0%

4.1-4.8	8 bit	Battery Capacity Estimation	1 Ah/bit	0
5.1-6.2	10 bit	Time Remaining	0.1 hour	0 hour

J1939 SPN Message Definitions

SPN (516150) Battery State of Charge
Supporting Information: The battery's present State of Charge, as the ratio of the battery's present charge, and the battery's charge when fully charged, reported as a percentage.

SPN (516151) Battery State of Health
Supporting Information: The battery's present State of Health, as the ratio of the battery's present health, and the battery's health when new, reported as a percentage.

SPN (516152) Battery Capacity Estimation
Supporting Information: The battery's estimated full capacity at present conditions at the 1C rate, reported in Ampere-hours (Ah).

SPN (516153) Time Remaining
Supporting Information: The amount of time it will take to discharge the battery to 0 percent SOC at the present rate of discharge.

PGN 65283

Description: Battery Regulation Information 1
Transmission Repetition Rate: 15000 ms, On Request (15000 ms by default)
Data Length: 8
Extended Data Page: 0
Data Page: 0
PDU Format: 255 (0xFF)
PDU Specific: 3 (0x03)
Default Priority: 5
Parameter Group Number: 65283
Data Field:

Position	Length	Parameter Name (SPN)	Resolution	Offset
1.1-2.8	16 bit	Bus Voltage Request	0.05V/bit	0V
3.1-4.8	16 bit	Open Circuit Voltage	0.05V/bit	0V

J1939 SPN Message Definitions

SPN (516154) Bus Voltage Request
Supporting Information: The vehicle bus voltage that would provide optimal battery charge based on the present condition of the battery.

SPN (516155) Open Circuit Voltage

Supporting Information: The estimated open circuit voltage of the battery based on the battery's present condition.

PGN 65284

Description: Battery Power Capability Prediction 1
Transmission Repetition Rate: 1000 ms to 15000 ms, On Request (15000 ms by default)
Data Length: 8
Extended Data Page: 0
Data Page: 0
PDU Format: 255 (0xFF)
PDU Specific: 4 (0x04)
Default Priority: 5
Parameter Group Number: 65284
Data Field:

Position	Length	Parameter Name (SPN)	Resolution	Offset
2.1-3.8	16 bits	Power Prediction (10s)	1 Watt/bit	0
4.1-5.8	16 bits	Power Prediction (30s)	1 Watt/bit	0

J1939 SPN Message Definitions

SPN (516156) Power Prediction (10s)

Supporting Information: A prediction for the maximum discharge power in Watts that the battery can sustain for a minimum of 10 seconds at its present condition while maintaining a voltage greater than the battery's terminal cutoff voltage specified in 4.4.6.1 d.

SPN (516157) Power Prediction (30s)

Supporting Information: A prediction for the maximum discharge power in Watts that the battery can sustain for a minimum of 30 seconds at its present condition while maintaining a voltage greater than the battery's terminal cutoff voltage specified in 4.4.6.1 d.

PGN 65285

Description: Configuration State Message 1
Transmission Repetition Rate: On Request
Data Length: 8
Extended Data Page: 0
Data Page: 0
PDU Format: 255 (0xFF)
PDU Specific: 5 (0x05)
Default Priority: 6
Parameter Group Number: 65285
Data Field:

Position	Length	Parameter Name (SPN)	Resolution	Offset
1.1-1.2	2 bits	Dormant 1 State	4 states/2 bits	0
1.3-1.4	2 bits	Dormant 2 State	4 states/2 bits	0
1.5-1.6	2 bits	Master Power Switch State	4 states/2 bits	0
1.7-1.8	2 bits	Configuration Pin 1 State	4 states/2 bits	0
2.1-2.2	2 bits	Configuration Pin 2 State	4 states/2 bits	0
2.3-2.4	2 bits	Configuration Pin 3 State	4 states/2 bits	0
2.5-2.6	2 bits	Configuration Pin 4 State	4 states/2 bits	0
2.7-2.8	2 bits	Configuration Pin 5 State	4 states/2 bits	0
3.1-3.2	2 bits	Configuration Pin 6 State	4 states/2 bits	0
3.3-3.4	2 bits	Virtual Master Power Switch State	4 states/2 bits	0
4.1-4.2	2 bits	Battery Battle-override State	4 states/2 bits	0
4.3-4.4	2 bits	Maintenance State	4 states/2 bits	0
4.5-4.6	2 bits	Automated Heater Function State	4 states/2 bits	0
4.7-4.8	2 bits	Battery Heater(s) State	4 states/2 bits	0
5.1-5.2	2 bits	Contactor(s) Control State	4 states/2 bits	0
5.3-5.4	2 bits	Contactor(s) State	4 states/2 bits	0
5.5-5.6	2 bits	Charge Capability State	4 states/2 bits	0
6.1-6.2	2 bits	Baud Rate Overwrite State	4 states/2 bits	0
6.3-6.4	2 bits	Position Identity Overwrite State	4 states/2 bits	0
6.5-6.6	2 bits	Configure VPMS Function State	4 states/2 bits	0
8.1-8.8	8 bits	SOC Reserve Limit Value	0.5%/bit	0%

J1939 SPN Message Definitions

SPN (516158) Dormant 1 State
Supporting Information: The value of dormant 1 on the communication interface as sensed by the battery.

00 Dormant 1 is off
01 Dormant 1 is on
10 Reserved
11 NA

SPN (516159) Dormant 2 State
Supporting Information: The value of dormant 2 on the communication interface as sensed by the battery.

00 Dormant 2 is off
01 Dormant 2 is on
10 Reserved
11 NA

SPN (516160) Master Power Switch State

Supporting Information: The value of Master Power Switch In on the communication interface as sensed by the battery.

00 Master Power Switch In is off
01 Master Power Switch In is on
10 Reserved
11 NA

SPN (516161) Configuration Pin 1 State
Supporting Information: The value of configuration pin 1 on the communication interface as sensed by the battery.

00 Configuration Pin 1 is false
01 Configuration Pin 1 is true
10 Reserved
11 NA

SPN (516162) Configuration Pin 2 State
Supporting Information: The value of configuration pin 2 on the communication interface as sensed by the battery.

00 Configuration Pin 2 is false
01 Configuration Pin 2 is true
10 Reserved
11 NA

SPN (516163) Configuration Pin 3 State
Supporting Information: The value of configuration pin 3 on the communication interface as sensed by the battery.

00 Configuration Pin 3 is false
01 Configuration Pin 3 is true
10 Reserved
11 NA

SPN (516164) Configuration Pin 4 State
Supporting Information: The value of configuration pin 4 on the communication interface as sensed by the battery.

00 Configuration Pin 4 is false
01 Configuration Pin 4 is true
10 Reserved
11 NA

SPN (516165) Configuration Pin 5 State

Supporting Information: The value of configuration pin 5 on the communication interface as sensed by the battery.

00 Configuration Pin 5 is false
01 Configuration Pin 5 is true
10 Reserved
11 NA

SPN (516166) Configuration Pin 6 State
Supporting Information: The value of configuration pin 6 on the communication interface as sensed by the battery.

00 Configuration Pin 6 is false
01 Configuration Pin 6 is true
10 Reserved
11 NA

SPN (516167) Virtual Master Power Switch State
Supporting Information: The present value of the Virtual Master Power Switch State

00 Virtual Master Power Switch is off
01 Virtual Master Power Switch is on
10 Reserved
11 NA

SPN (516168) Battery Battle-override State
Supporting Information: State of Battery Battle Override Mode

00 Battery Battle-override Disabled
01 Battery Battle-override Enabled
10 Reserved
11 NA

SPN (516169) Maintenance State
Supporting Information: Maintenance State status

00 Battery is not in the Maintenance State
01 Battery is in the Maintenance State
10 Reserved
11 NA

SPN (516170) Automated Heater Function State
Supporting Information: State of the Automated Heater Function

00 Automated Heater Function is disabled
01 Automated Heater Function is enabled

10 Reserved
11 NA

SPN (516171) Battery Heater(s) State
Supporting Information: State of the Battery Heater(s)

00 Battery heater is off
01 Battery heater is on
10 Reserved
11 NA

SPN (516172) Contactor(s) Control State
Supporting Information: State of the Battery Contactor

00 Contactor(s) control is not automatic (state forced by command)
01 Contactor(s) control is automatic
10 Reserved
11 NA

SPN (516173) Contactor(s) State
Supporting Information: State of the Battery Contactor
00 Contactor(s) is open
01 Contactor(s) is closed
10 Reserved
11 NA

SPN (516174) Charge Capability State
Supporting Information: State of battery's capability to charge

00 Battery is unable to accept charge
01 Battery is able to accept charge
10 Reserved
11 NA

SPN (516175) Baud Rate Overwrite State
Supporting Information: Baud Rate Overwritten status

00 Baud Rate has not been overwritten
01 Baud Rate has been overwritten
10 Reserved
11 NA

SPN (516176) Position Identity Overwrite State
Supporting Information: Position Identity Overwritten status

00 Position identity has not been overwritten

01 Position identity has been overwritten
10 Reserved
11 NA

SPN (516177) Configure VMPS Function
Supporting Information: State of the Configure VMPS Function

00 VMPS Function Disabled
01 VMPS Function Enabled
10 Reserved
11 NA

SPN (516178) SOC Reserve Limit Value
Supporting Information: Configured value for the SOC Reserve Limit

00 – C8 0% to 100% SOC limit
FE Error
FF NA

PGN 65286

Description: Protected State Message 1
Transmission Repetition Rate: 1000 ms, only when Protected State Warning = 000, 001, 010, or 011. Otherwise, On Request.
Data Length: 8
Extended Data Page: 0
Data Page: 0
PDU Format: 255 (0xFF)
PDU Specific: 6 (0x06)
Default Priority: 3
Parameter Group Number: 65286
Data Field:

Position	Length	Parameter Name (SPN)	Resolution	Offset
1.1-1.3	3 bits	Protected State Warning	8 states/2 bits	0
2.1-2.8	8 bits	Failed Exit Attempts Count	1 count/bit	0
3.1-4.8	16 bits	Protected State Timeout	1 second/bit	0

J1939 SPN Message Definitions

SPN (516179) Protected State Warning
Supporting Information: Warnings the battery shall provide when it is approaching a limit that may transition the battery to the Protected State, and when the battery is in the Protected State.

000_2 Battery is in the Protected State.
001 Warning 1. Battery could transition to the Protected State within 1-2 seconds.

010	Warning 2. Battery could transition to the Protected State within 3-10 seconds.
011	Warning 3. Battery could transition to the Protected State within 11-30 seconds.
100	Reserved.
101	Reserved.
110	Reserved.
111	NA

SPN (516180) Failed Exit Attempts Count
Supporting Information: A count of the number of attempts that have been made by the battery or by command that have failed to transition the battery out of the Protected State.

$0\text{-}FA_{16}$	Count of the number of failed attempts
FB	Count exceeded maximum
FC	Reserved
FD	Reserved
FE	Error
FF	NA

SPN (516181) Protected State Timeout
Supporting Information: The amount of time before the battery automatically attempts to exit the Protected State.

$0\text{-}FAFF_{16}$	Time in seconds before the attempt to exit the Protected State
FB00	Battery requires “Reset Protection” command to exit Protected State
FB01	No timeout for fault
FB02-FDFF	Reserved
FExx	Error
FFxx	NA

Custodians:
Army - AT
DLA - CC

Preparing activity:
Army - AT
(Project 6140-2016-004)

Review activities:
Army – CR

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.