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SURFACE VEHICLE STANDARD

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(R) STORAGE BATTERIES FOR OFF-ROAD SELF-PROPELLED WORK MACHINES

***Foreword*—**This Document has also changed to comply with the new SAE Technical Standards Board format.

1. *Scope*

***Scope*—**This SAE Standard applies to all types of heavy-duty storage batteries for use on off-road machines as described in SAE J1116. Included are definitions of industry terms, test procedures, general requirements, application recommendations, standard sizes, overall dimensions, and electrical values.

1.1 Lead Acid Storage Battery Types—Battery types covered by this document include, but are not limited to, the following:

1.1.1 LOW MAINTENANCE—Battery types which require periodic watering during use. These battery types shall have a method of accessing the electrolyte.

1.1.2 MAINTENANCE FREE—Battery types which do not require periodic watering during use. These battery types may or may not have access to the electrolyte.

1.1.3 VALVE REGULATED—Battery types which contain absorbed or gelled electrolyte. These batteries do not permit access to electrolyte and are maintenance free.

1.2 Battery Performance Ratings—Performance ratings shall be at a 90% compliance level as described in SAE J537, 1.1.

2. *References*

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

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J180 MAY87—Electrical Charging Systems for Construction and Industrial Machinery
SAE J537 JUN92—Storage Batteries
SAE J538 AUG83—Grounding of Storage Batteries
SAE J821 MAY85—Electrical Wiring System for Construction, Agricultural and Off-Road Machines
SAE J1116 JUN86—Categories of Off-Road Self-Propelled Work Machines
SAE J1127 JAN95—Battery Cable
SAE J1310 APR81—Electric Engine Preheaters and Battery Warmers for Diesel Engines
SAE J1495 MAR92—Test Procedure for Battery Flame Retardant Venting Systems

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SAE J1811 JAN95—Power Cable Terminals
SAE J2185 NOV91—Life Test for Heavy-Duty Storage Batteries

2.1.2 BATTERY COUNCIL PUBLICATION—Available from Battery Council International, 401 N. Michigan Ave., Chicago, Illinois, 60611.

Battery Technical Manual

3. Definitions

3.1 CCA—Cold Cranking Amperes at –18 °C as defined in 7.3.3.

3.2 ORM—Off-Road Work Machine or Off-Road Work Machinery as defined in SAE J1116.

3.3 ORMCCA—Off-Road Machinery Cold Cranking Amperes at –18 °C as defined in 7.3.5 but is run for 60 s with end voltage at 1.0 V or greater per cell.

3.4 RC—Reserve Capacity in minutes at 25 °C as defined in 7.3.2.

4. Battery Sampling and Sequence of Tests

4.1 Battery samples selected for compliance to this document shall be new, unused, previously untested, and no older than 60 days from date of manufacture.

4.1.1 DANGER OF EXPLODING BATTERIES—Batteries contain sulfuric acid and they produce explosive mixtures of hydrogen and oxygen. Because self-discharge action generates hydrogen gas when the battery is not in operation, make sure batteries are stored and worked on in a well ventilated area. ALWAYS wear safety goggles and a face shield when working on or near batteries. When working with batteries:

a. Always wear proper eye, face, and hand protection.
b. Keep all sparks, flames, and cigarettes away from the battery.
c. Do not remove or damage vent caps.
d. Cover vent caps with a damp cloth.
e. Make sure work is well ventilated.
f. Never lean over battery while boosting, testing, or charging.

4.2 Battery performance and rating tests shall be performed in the sequence as shown in Table 1:

Table 1—SEQUENCE FOR BATTERY PERFORMANCE AND RATING TESTS

Event Sequence	Description	Test Ref. No.
1	Dry charged activation	Per manufacturer's instr.
2	Charging and conditioning	Reference 7.3.1
3	Reserve Capacity (RC)	Reference 7.3.2
4	Charge Rate Acceptance	Reference 7.3.4
5	Cold Cranking test	For CCA, Reference 7.3.3
		For ORMCCA, Reference 7.3.5
6(1)	Reserve Capacity (RC)	Reference 7.3.2
7(1)	Cold Cranking test	For CCA, Reference 7.3.3
		For ORMCCA,Reference 7.3.5
8(1)	Reserve Capacity (RC)	Reference 7.3.2

1. Battery samples which meet ratings in events 3 and 4 do not require test events 6, 7, and 8.

4.3 Perform Water Loss Test per Section 5.

4.4 Perform Self-Discharge Test per Section 6.

4.5 Perform General Requirements tests per Section 7 as follows:

4.5.1 Vent System per 7.1

4.5.2 Tilt Test per 7.2

4.5.3 Vibration per 7.4

4.5.4 Deep Discharge Recovery Test per 7.5

4.5.5 Remote Venting per 7.6

4.5.6 Handles or Lifting Devices per 7.7

4.5.7 Battery Life Test per 7.9

5. Water Loss Evaluation—The rate at which a battery uses water, i.e., generates gas, is *influenced* by factors such as charging voltage, operating temperature, grid alloys, element design, and materials, etc. A test that provides an indication of the rate of water loss by using steady-state current is described in the following sections:

5.1 Conditioning and Charging—Condition and recharge sample battery as follows:

5.1.1 Condition sample battery per 7.3.1

5.1.2 Perform one Reserve Capacity (RC) test per 7.3.2

5.1.3 Recharge sample per 7.3.1

5.1.4 Depending on battery rating, perform one CCA test per 7.3.3 or ORMCCA test per 7.3.5

5.1.5 Recharge sample battery per 7.3.1

5.2 Soak Period—Place the fully charged battery in an oven or a circulating water bath maintained at a temperature of 52 °C ± 0.5 °C for 16 h. Very large batteries may require a longer period to reach a stabilized temperature which is indicated by a change in center cell temperature of less than 3 °C over a 1 h period. Charge at 2.35 V per cell ± 0.05 V per cell (7.05 V ± 0.05 V for a 6-V system and 14.1 V ± 0.05 V for a 12-V system) during the soak period.

5.3 Test Measurements—While charging the battery, measure the charging current every 15 min. When the charging current stabilizes (i.e., less than a 2 mA change between successive readings) record the current and stop the test.

5.4 Interpretation of Results—Water loss is proportional to the steady-state charging current and is approximately 0.336 mL (or 624 cc's of gas generated at Standard Temperature and Pressure) per ampere hour per cell. The Off-Road Work Machinery manufacturer and battery supplier should jointly determine acceptable rates for the specific application involved.

6. Self-Discharge Test—The rate of battery self-discharge depends on grid alloy, impurities in the electrolyte, temperature, etc. A test procedure for determining the rate of battery self-discharge is listed as follows:

6.1 Conditioning and Charging—Condition and recharge sample battery as follows:

6.1.1 Condition sample battery per 7.3.1.

6.1.2 Perform one Reserve Capacity (RC) test per 7.3.2.

6.1.3 Recharge sample battery per 7.3.1.

6.1.4 Depending on battery rating, perform one CCA test per 7.3.3 or ORMCCA test per 7.3.5.

6.1.5 Recharge sample battery per 7.3.1.

6.2 Initial Reserve Capacity

6.2.1 Perform one Reserve Capacity (RC) test per 7.3.2. Record this information as Initial Reserve Capacity (RCI).

6.2.2 Recharge battery per 7.3.1.

6.3 Soak Period—Place the fully charged but disconnected battery, which is disconnected from the charger, in an oven or circulating water bath at a temperature of 41 °C ± 1 °C for 28 days.

6.4 Unboosted Reserve Capacity

6.4.1 At the end of the 28th day, remove sample battery from the 41 °C ± 1 °C soak environment.

6.4.2 Cool the sample battery to 27 °C ± 3 °C within 48 h.

6.4.3 Perform Unboosted Reserve Capacity test. Record this as Final Reserve Capacity (RCF).

6.5 Calculation of Self-Discharge Loss—Calculate the percent loss in Reserve Capacity as follows in Equation 1:

$$\text{Percent self-discharge loss} = \frac{RCI - RCF}{RCI} \times 100 \quad \text{(Eq. 1)}$$

where:

RCI = initial reserve capacity, minutes
RCF = final reserve capacity, minutes

6.6 Interpretation of Results—Batteries will lose a portion of their capacity under this test; however, the Off-Road Machinery manufacturer and battery supplier should jointly determine an acceptable loss for the specific application involved.

7. General Requirements

7.1 Vent System—Must meet requirements specified in SAE J1495 as well as the Tilt tests described as follows:

7.2 Tilt Tests for Electrolyte Loss

7.2.1 STATIC TILT TEST—No electrolyte shall be lost from the battery when tested as follows:

7.2.1.1 Sample battery is to be conditioned as described in 7.3.1 and filled to its recommended level when appropriate.

7.2.1.2 Sample battery shall be at a temperature of 27 °C ± 3 °C.

7.2.1.3 *Caution*—Carefully tilt the battery sample to prevent electrolyte sloshing.

Tilt sample battery to a 45 degree angle from the normal at rest position for 2 h in each of the following four positions: fore and aft, as well as side to side. The last tilt position shall be with the side containing a single vent outlet (if any), in the downward position.

7.2.2 CHARGING TILT TEST—No electrolyte shall be lost from the battery when tested as follows:

7.2.2.1 Sample battery is to be conditioned as described in 7.3.1 and filled to its recommended level when appropriate.

7.2.2.2 Sample battery shall be at a temperature of 27 °C ± 3 °C.

7.2.2.3 *Caution*—Carefully tilt the battery sample to prevent electrolyte sloshing.

Tilt sample battery to a 45 degree angle from the normal at rest position for 15 min in each of the following four positions: fore and aft, as well as side to side. The last tilt position shall be with the side containing a single vent outlet (if any), in the downward position. While in each of the four positions noted, charge the battery at 2.35 V per cell (14.1 V ± 0.1 V for a 12-V system).

7.3 Electrical Performance Test Requirements

7.3.1 All battery samples shall be conditioned and charged per SAE J537, 3.2.

7.3.2 Reserve Capacity (RC) performance requirements and test procedures shall be per SAE J537, 3.5 at the battery manufacturer's rating.

7.3.3 Cold Cranking Ampere (CCA) performance requirements and test procedures shall be per SAE J537, 3.7 at the battery manufacturer's rating.

7.3.4 Charge Rate Acceptance performance requirements and test procedures shall be per SAE J537, 3.6 at the battery manufacturer's rating.

7.3.5 Off-Road Machinery Cold Cranking Ampere (ORMCCA) performance requirements and test procedures are as follows:

This test is run at –18 °C and acknowledges that extra cranking time is often needed for ORM equipment during engine starting. Cold Diesel engine starting (sometimes with electrical and other parasitic loads), requires an ORMCCA rating which differentiates a battery from the CCA rating defined in 7.3.3 or the battery manufacturers rating.

Sample battery shall be tested per SAE J537, 3.7 with the additional requirement that discharge duration shall be for 60 s while continuing to measure battery terminal voltage under load.

The acceptance criteria for this test is that battery voltage shall be 1.2 V per cell or greater at 30 s, and 1.0 V per cell or greater at 60 s.

7.4 Vibration—In order to provide an optimum design, as dictated by the application, one of three amplitude-time levels can be specified. The Off-Road Machine manufacturer and the Battery supplier must determine which level and number of vibration units is required for the application involved. The following procedure shall be used to test batteries in ORM applications.

7.4.1 Condition (2) sample batteries per 7.3.1.

7.4.2 Perform one Reserve Capacity (RC) test on each sample per 7.3.2.

7.4.3 Recharge sample batteries per 7.3.1.

7.4.4 Depending on battery rating, perform one CCA test per 7.3.3, or ORMCCA test per 7.3.5 on each sample.

7.4.5 Recharge sample batteries per 7.3.1.

7.4.6 Fully charged batteries shall be set up and vibrated as outlined in SAE J537 at a frequency of 30 to 36 Hz. One unit of vibration is the time shown as follows for the selected level:

One unit of Level 1 vibration = 3.5 G ± 0.2 G's for 8 h
One unit of Level 2 vibration = 5.0 G ± 0.2 G's for 18 h
One unit of Level 3 vibration = 5.0 G ± 0.2 G's for 36 h

For testing purposes interruption of these time periods is permissible.

7.4.7 After each unit of vibration, samples shall be tested and meet performance requirements described in SAE J537, 3.8.4.2.6, when tested at the battery manufacturer's rating.

7.5 Deep Discharge Recovery Test—This test is to evaluate a battery's ability to recover after it has been discharged and allowed to sit for period of time before being recharged. Proceed as follows:

7.5.1 Sample battery is to be conditioned as described in 7.3.1.

7.5.2 Discharge the battery at 1% of the rated CCA or ORMCCA to 1.75 V per cell (i.e., 10.5 V for a 12-V battery).

7.5.3 Place the battery in an area where the temperature is maintained at 27 °C ± 3 °C. Connect a resistor of approximately 4.5 Ω between the battery terminals and leave connected for 30 days.

7.5.4 On the 31st day, remove the resistor and immediately charge the battery at 2.66 V per cell (16.0 V ± 0.05 V for 12-V battery) at 27 °C ± 3 °C. Use a charger which can provide a current of at least 5% of the battery CCA rating.

The battery shall accept at least 1% of the CCA rating within a 1 h period.

7.5.5 Finish recharging the battery per 7.3.1.

7.5.6 Perform one test per 7.3.3 or 7.3.5 at 90% of the discharge current rating.

The acceptance criterion for this test is that battery voltage shall be 1.2 V per cell or greater at 30 s or 1.0 V per cell at 60 s.

7.6 Remote Venting—When remote venting is required, the battery shall provide venting exits to which a vent tube extension can be attached. Venting exits and vent tube extensions shall be arranged so that vent flow does not become restricted or sealed closed by surrounding components such as battery hold-down devices, cables, battery compartment walls, etc.

7.7 Handles or Lifting Devices—Batteries equipped with lifting devices shall meet the following:

With the battery in its normal at-rest position and maintained at a stabilized temperature of 25 °C ± 3 °C, each lifting device must be able to withstand a vertically applied static load equal to twice the mass of the battery and a horizontally applied static load equal to the mass of the battery, each applied for a period of 30 min.

7.8 Battery Sizes—Overall dimensions and SAE numbers are shown in SAE J537.

7.8.1 Configuration and terminal locations are shown in SAE J537 chart A2.

7.8.2 Electrical ratings and overall dimensions are shown in SAE J537 chart A1.

7.9 Battery Life Test—See SAE J2185 for heavy-duty storage battery life testing.

8. Application Guidelines—The design and location of the battery tray or carrier may be as important as the selection of the battery itself. The following recommendations, if applied, can contribute to optimizing battery life in Off-Road Machine applications.

8.1 Vibration Considerations—Battery trays or carriers should be located to minimize the damaging effects of vibration, especially at frequencies ranging from 3 to 50 Hz. Generally, vibration problems can be minimized by mounting the batteries near the main frame and as close to the center of the machine as possible.

8.2 Environmental Protection—Batteries should be located in a clean environment and protected from the accumulation of mud, dirt, water, and other foreign materials which may block vents, enter the batteries during watering, or contribute to terminal corrosion. Dirty battery tops provide current leakage paths which contribute to high battery self-discharge rates and shortened battery life.

8.3 Ventilation (of Battery Location)—Batteries produce hydrogen and oxygen gases as natural by-products of normal operation. These gases may collect in flammable and potentially explosive concentrations around the batteries (if the location is not well ventilated). Batteries shall be located to allow adequate ventilation that will dissipate these gases in a manner that keeps them away from potential ignition sources such as sparks, flames, and the exhaust system. Where batteries are mounted in an enclosure, adequate venting and air circulation shall be provided.