



SURFACE VEHICLE STANDARD

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Storage Batteries for Off-Road Self-Propelled Work Machines

RATIONALE

Several members of the Starter Battery Committee have met to review the current status of SAE J930. We do not envision any changes to the standard, as it has been unmodified for a significant period of time. Therefore, the recommendation is being made to the full Starter Battery Committee to stabilize this document.

STABILIZED NOTICE

This document has been declared "STABILIZED" by SAE Starter Battery Standards Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. 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

Flooded Battery types which require periodic watering during use. These battery types shall have a method of accessing the electrolyte.

1.1.2 Maintenance Free

Flooded 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 (VRLA)

Battery types which contain absorbed (AGM) or gelled (Gel) 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.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

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

SAE J180	Electrical Charging Systems for Construction and Industrial Machinery
SAE J537	Storage Batteries
SAE J538	Grounding of Storage Batteries
SAE J821	Electrical Wiring System for Construction, Agricultural and Off-Road Machines
SAE J1116	Categories of Off-Road Self-Propelled Work Machines
SAE J1127	Battery Cable
SAE J1310	Electric Engine Preheaters and Battery Warmers for Diesel Engines
SAE J1495	Test Procedure for Battery Flame Retardant Venting Systems
SAE J1811	Power Cable Terminals
SAE J2185	Life Test for Heavy-Duty Storage Batteries
SAE J2981	Starter Battery Identification and Classification
SAE J3060	Automotive and Heavy Duty Storage Battery Vibration

2.1.2 Battery Council International Publications

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 (0°F) as defined in 7.3.3.

3.2 ORM

Off-Road Work Machine or Equipment as defined in SAE J1116.

3.3 RC

Reserve Capacity in minutes at 25°C (77°F) 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. This may not be possible when sampling at the retail level. Battery date codes, and ship codes should be recorded and included with test results.

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. Make sure work is well ventilated. Any chamber, or oven used for battery testing, charging or discharging should have an operational hydrogen detection system and an explosion proof ventilation system designed to avoid the buildup of hydrogen gas
- e. 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
6 ⁽¹⁾	Reserve Capacity (RC)	Reference 7.3.2
7 ⁽¹⁾	Cold Cranking test	For CCA, Reference 7.3.3
8 ⁽¹⁾	Reserve Capacity (RC)	Reference 7.3.2

¹ Battery samples which meet ratings in events 3 and 5 do not require test events 6, 7, and 8.

* Test event 4 can be made optional at the request of customer when testing for continuing conformation to specifications

- 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 in flooded batteries by using steady-state current is described in the following sections. This test shall not apply to VRLA batteries.

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 Using the manufacturer's battery rating, perform one CCA test per 7.3.3 Recharge sample battery per 7.3.1

5.2 Soak Period

Place the fully charged battery in an oven, which should be equipped with a hydrogen detection system and explosion proof ventilation system, or a circulating water bath maintained at a temperature of $52\text{ }^{\circ}\text{C} \pm 0.5\text{ }^{\circ}\text{C}$ ($125^{\circ}\text{F} \pm 1.0^{\circ}\text{F}$) for 16 hours. 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 $3\text{ }^{\circ}\text{C}$ over a 1 hour period. Charge at $2.35\text{ V per cell} \pm 0.05\text{ V per cell}$ ($7.05\text{ V} \pm 0.05\text{ V}$ for a 6-V system and $14.1\text{ V} \pm 0.05\text{ V}$ for a 12-V system) during the soak period.

5.3 Test Measurements

While charging the battery, measure the charging current every 15 minutes. When the charging current stabilizes (i.e., less than a 2 mA change between successive readings) record the current and then 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 Using the manufacturer's battery rating, perform one CCA test per 7.3.3 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, which should be equipped with a hydrogen detection system and explosion proof ventilation system or circulating water bath at a temperature of $41\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($105\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$) for 28 days.

6.4 Unboosted Reserve Capacity

6.4.1 At the end of the 28th day, remove sample battery from the $41\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($105\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$) soak environment.

6.4.2 Cool the sample battery to $27\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($80\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$) within 48 hours.

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:

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

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

All batteries, both flooded and VRLA batteries shall meet the requirements specified in SAE J1495. Flooded battery types also shall meet the requirements of the Tilt tests described in 7.2.

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 $27^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($80^{\circ}\text{F} \pm 5^{\circ}\text{F}$).

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 120 minutes $\pm$ 0.5 minutes 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 $27^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($80^{\circ}\text{F} \pm 5^{\circ}\text{F}$).

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 minutes $\pm$ 0.5 minutes 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 ($14.1\text{ V} \pm 0.05\text{ V}$ 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.

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

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

7.3.4 Charge Rate Acceptance performance requirements and test procedures shall be per SAE J537, at the battery manufacturer's rating. This is an optional test when testing for electrical compliance or ratings compliance

7.4 Vibration See SAE J3060 for heavy duty battery vibration testing

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 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 $27^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($80^{\circ}\text{F} \pm 5^{\circ}\text{F}$). Connect a resistor of approximately $4.5\ \Omega$ between the battery terminals and leave connected for 30 days.

7.5.4 On the 31st day, remove the resistor and immediately charge a flooded battery at 2.66 V per cell ($16.0\text{ V} \pm 0.05\text{ V}$ for 12-V battery). For a VRLA battery, charge at 2.40 to 2.47 V per cell ($14.4\text{ to }14.8\text{ V} \pm 0.05\text{ V}$ for a 12-V battery), or the manufacturers recommended recharge voltage, but not less than 2.33 V per cell ($14.0\text{ V} \pm 0.05\text{ V}$ for a 12-V battery) at $27^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($80^{\circ}\text{F} \pm 5^{\circ}\text{F}$). 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 hour period.

7.5.5 Finish recharging the battery per 7.3.1.

7.5.6 Perform one test per 7.3.3 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 seconds.

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 $25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($77^{\circ}\text{F} \pm 5^{\circ}\text{F}$), 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 J2981.

7.8.1 Configuration and terminal locations are shown in SAE J2981.

7.8.2 Electrical ratings and overall dimensions are shown in SAE J2981.

7.9 Battery Life Test

See SAE J2185 for heavy-duty storage battery life testing.