| | | |
|---|---|---|
| SAE International® | SURFACE VEHICLE STANDARD | SAE J180 MAY2012 |
| | | Issued 1970-06<br>Revised 2012-05<br><br>Superseding J180 JAN2002 |

# Electrical Charging Systems for Off Highway Work Machines

RATIONALE

This document describes uniform requirements for heavy duty 12 V and 24 V charging systems.

## 1. SCOPE

This SAE document describes alternator physical, performance and application requirements for heavy-duty electrical charging systems for off road work machines including those defined in SAE J1116.

### 1.1 Purpose

The purpose of this SAE document is to provide information on which to base machine and component design and to establish minimum requirements which will result in the most satisfactory operation of charging systems in construction, agricultural, and industrial machinery environments.

## 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 724-776-4970 (outside USA), www.sae.org.


SAE J56 Road Vehicles - Alternators with Regulators - Test Methods and General Requirements

SAE J537 Storage Batteries

SAE J551-1 Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)

SAE J551-2 Test Limits and Methods of Measurement of Radio Disturbance Characteristics of Vehicles, Motorboats, and Spark-Ignited Engine-Driven Devices

SAE J551-4 Test Limits and Methods of Measurement of Radio Disturbance Characteristics of Vehicles and Devices, Broadband and Narrowband, 150 kHz to 1000 MHz

SAE J930 Storage Batteries for Off-Road Self-Propelled Work Machines

SAE J1113-11 Immunity to Conducted Transients on Power Leads

SAE J1116 Categories of Off-Road Self-Propelled Work Machines

SAE J1455 Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications

SAE J2669 Voltage Regulators for Automotive-Type Generators

#### 2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B 117 Standard Practice for Operating Salt Spray (Fog) Apparatus

## 3. DEFINITIONS

### 3.1 NORMAL CHARGING SYSTEM OPERATION

Normal charging system operation includes an alternator that generates electrical energy from a mechanical source, a voltage regulator to control the alternator output voltage, and a battery that provides a standby source of electrical energy. Further information on voltage regulators is found in SAE J2669, and on battery specifications is found in SAE J537 and SAE J930.

### 3.2 BATTERYLESS OPERATION

Batteryless operation occurs in a machine application whenever the battery becomes disconnected from the alternator. The electrical load of the alternator is significantly different in this situation. The disconnection may be intentional or unintentional. In some applications, machines are shipped for export without batteries. In this situation, a slave battery may be used for jump starting the machine. After the machine is started, the battery is disconnected and the machine is moved. During movement the alternator is operating without the battery and expected to power such items as the engine control unit, transmission control unit, and engine fuel solenoids.

Batteryless operation can also occur during operational usage whenever there is:

a. A battery open cell failure

b. The battery becomes extremely sulfated

c. The connections to the battery become loose

d. The connections to the battery become corroded

e. A master disconnect switch becomes open or its connections become open

The effect of the alternator operating in a batteryless situation is typically a wider range of voltages in output than when loaded with a battery. Some alternators do not produce output without a battery or voltage regulation may become unstable.

### 3.3 REVERSE POLARITY

Reverse polarity occurs when the battery positive and negative cables are hooked up in reverse. This condition normally results in damage to the alternator and to any other semiconductor loads that experience the reverse polarity hookup.

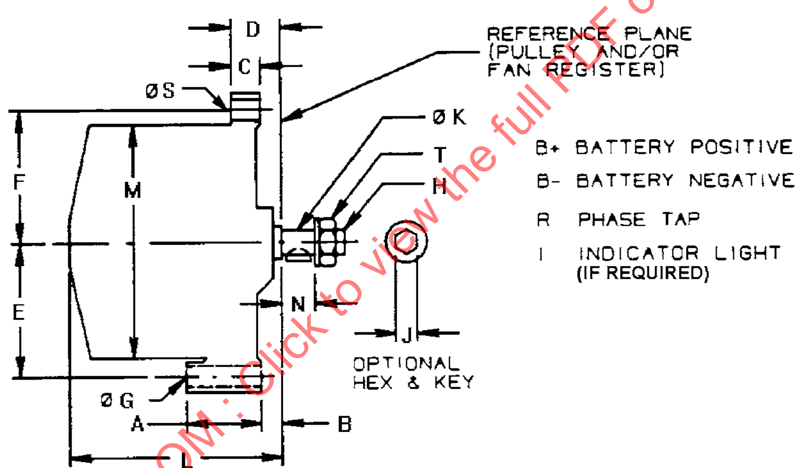
### 3.4 LOAD DUMP

A sudden interruption of most electrical loads from the alternator during alternator operation causes a self-induced voltage surge named load dump. Load dump could be caused by such items as connections to the alternator B+ terminal becoming loose, connections to the alternator B+ terminal being corroded, defective alternator output cables, etc. The effect of a load dump is the presence of voltage spikes significantly exceeding system voltage and may exceed the voltage breakdown limits of some electrical components to cause damage.

## 4. PHYSICAL REQUIREMENTS

### 4.1 Dimensional

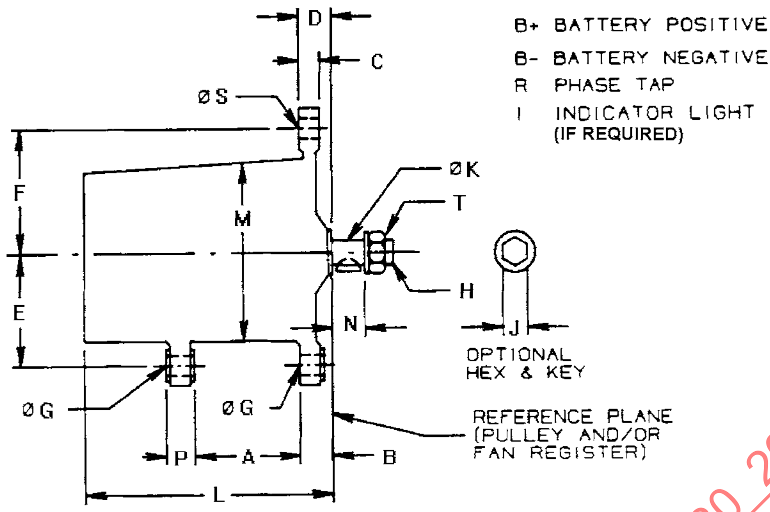
Figure 1 portrays a spool-mount alternator. Figure 2 portrays a hinge mount alternator. Figure 3 portrays a pad mount alternator. Included in all are alternator shaft hub dimensions.




| A ◊ | B ◊ | C | D | E Max | F Max | G | H | J | K ◊ | L Max | M Max | N | S | T Torque Max | Terminals B+ | B- | R | I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 21 | 16 | 32 | 105 | 105 | 10 | 5/8 or M16 | 8 | 17 or 22.2 | 170 | 180 | 20 | 10 or M8 | 65 Nm | 5/16 or M10 | 1/4 or M6 | #10 or M4 | #10 or M4 |

Note: Unless indicated all dimensions are nominal.
◊ is a critical dimension

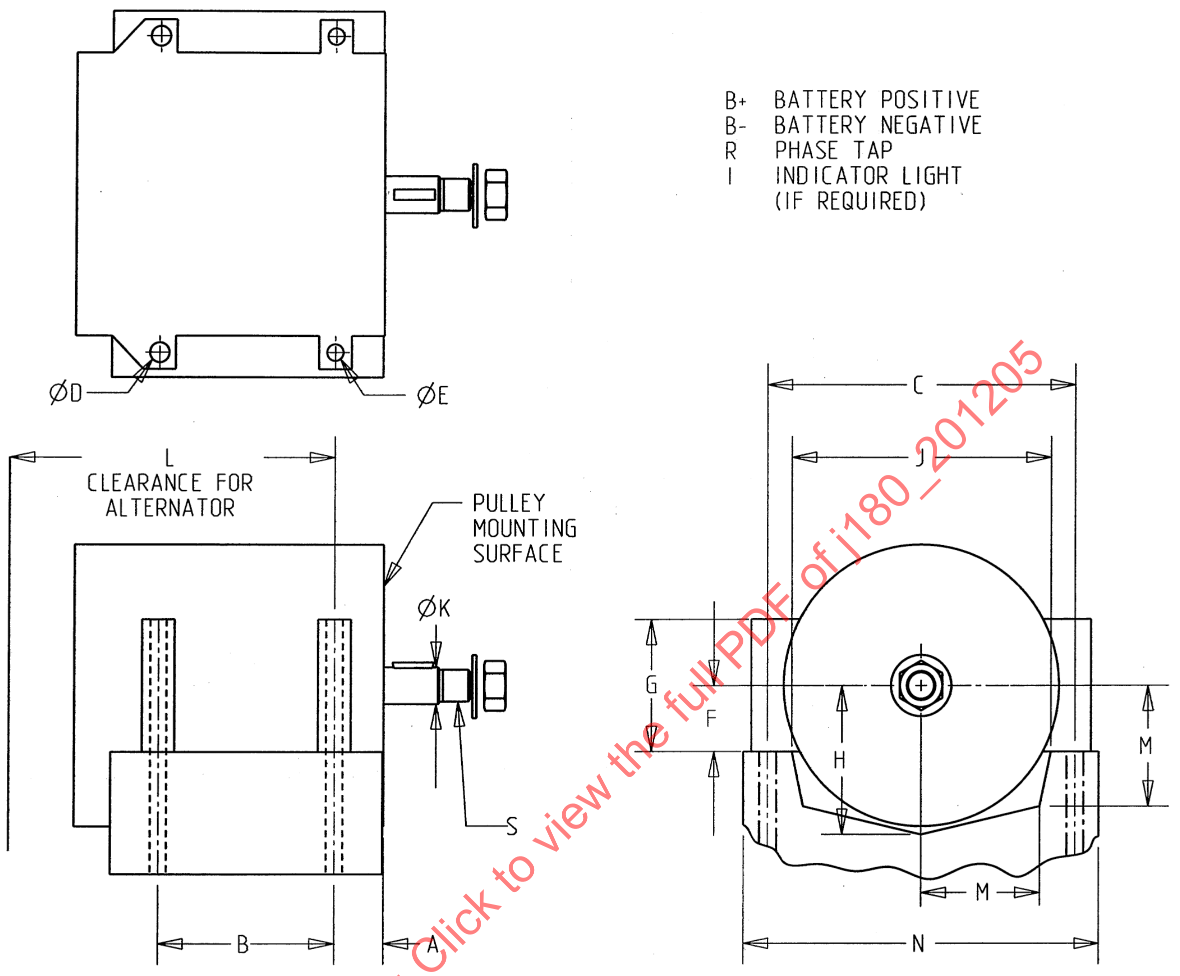
FIGURE 1 - ALTERNATOR DIMENSIONS FOR SPOOL MOUNTING




| A ◊ | B ◊ | C | D | E Max | F Max | G | H | J | K ◊ | L Max | M Max | N | P | S | T Torque Max | Terminals B+ | Terminals B- | Terminals R | Terminals I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 30 | 14.5 | 30 | 120 | 115 | 13 | 5/8 or M16 | 8 | 22.2 | 280 | 205 | 40 | 20 | 1/2 or M12 | 108 Nm | 7/16 or M12 | 1/4 or M6 | 3 mm Dia. Pin or M4 | #10 or M4 |

Note: Unless indicated all dimensions are nominal.
◊ is a critical dimension

FIGURE 2 - ALTERNATOR DIMENSIONS WITH HINGE MOUNTING






| VERSION | A◊ | B◊ | C◊ | D | E | F | G | H* | *J◊ | K | L | M* | N* | S | TERMINALS B+ | B- | R | I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 190-1 | 30.1 | 108 | 190 | 12.5 | 10.5 | 40 | 80 | 90 | 160 | 22.2 | 200 | 73 | 220 | 5/8 OR M20 | 3/8 OR M10 | 5/16 OR M8 | 1/4 OR M6 | 1/4 OR M6 |
| 190-2 | 30.1 | 126.3 | 190 | 12.5 | 10.5 | 40 | 80 | 90 | 160 | 22.2 | 200 | 73 | 220 | | | | | |

NOTE: UNLESS INDICATED ALL DIMENSIONS ARE NOMINAL
◊ IS A CRITICAL DIMENSION
* BRACKET DIMENSION

NOTES:

1 - Four M10 bolts recommended for mounting alternator with 40 NM torque.

2 - Diameter D intended for additional mounting bolt clearance.

3 - Brackets may have additional holes to accommodate 190-1 and 190-2 versions on the same bracket.

FIGURE 3 - ALTERNATOR AND BRACKET DIMENSIONS FOR PAD MOUNT

## 4.2 Mounting Recommendations

### 4.2.1 Hinge Mounting

Figure 4 shows a hardened split bushing in the alternator mounting lug opposite the drive end. The mounting bolt clamps the mounting bracket to this bushing. Tightening of the mounting bolts positions the bushing, easing strain on bracket and lugs.

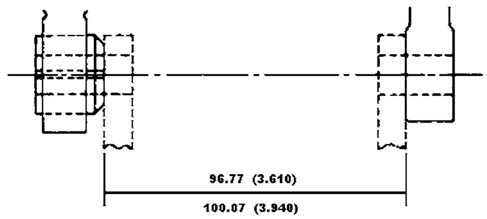



FIGURE 4 - TYPICAL INSTALLATION OF SPLIT BUSHING IN HINGE MOUNTING LUG

### 4.2.2 Spool Mounting

Figure 5 shows the hardware and brackets for spool mounting. A hardened, split bushing is located in the mounting bracket.

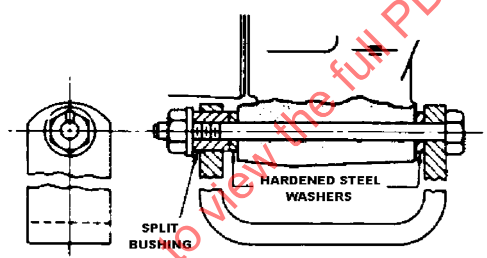



FIGURE 5 - TYPICAL INSTALLATION OF SPLIT BUSHING IN BRACKET FOR SPOOL MOUNTING

### 4.2.3 Pad Mounting

A single piece pad mount bracket is recommended over multi piece pad mount bracket. Hardened washers under nuts and under mounting bolts are required.

## 4.3 Terminals

On all alternators, provisions shall be made for a negative ground connection, either by a terminal post or a threaded hole, to insure a sound electrical ground path from the alternator to the machine system ground.

To insure correct electrical connection between the alternator and the mating wiring harness, and to standardize on terminals between the various alternator manufacturers, terminal sizes are recommended in Figures 1, 2, and 3.

Blade type external terminations are not recommended to be used on alternators that are covered by this SAE document.

## 4.4 Alternator Drive Configuration

See Figures 1, 2, and 3 for shaft sizes and drive alignment reference.

4.5 Alternator Identification

The alternator nameplate shall be visible in its normal mounting orientation. Each alternator shall be identified with the following characteristics:

Manufacturer's Identification, Part Number, Voltage Rating, Current Rating, Manufacturing Plant, and Manufacturing Date Code (and/or Serial Number).

## 5. PERFORMANCE REQUIREMENTS

### 5.1 Performance

Refer to SAE J56 for performance and test procedure.

### 5.2 Regulation

Refer to SAE J2669 for voltage regulator performance and battery charge voltage and temperature compensation.

### 5.3 Batteryless Application

The machine designer shall consider the probability of open-circuit operation and accidentally induced high transient voltage. The designer shall define the conditions (maximum speed, maximum load change, repetition rate) to the alternator manufacturer and specify the maximum voltage (peak and duration) tolerable to the load components of the electrical system.

The average steady-state alternator system output terminal voltage, with battery disconnected and a minimum resistive load of 60 Ω, shall not rise by more than 10% when compared to the allowable voltage with the battery connected.

### 5.4 Load Dump

The alternator system, including all associated rectifying, regulating, and filtering devices, shall withstand the self-induced voltage surge resulting from the sudden disconnection (not longer than 20 ms to complete break) of the output current (including battery) at 6000 rpm and maximum possible output at that speed. This test shall be conducted a minimum of five (5) consecutive times. Reference SAE J1113-11 test requirements. Alternators that utilize zener rectifiers shall be self suppressed to limit output voltages to 60V maximum.

## 6. APPLICATION REQUIREMENTS

### 6.1 Dust

The alternator shall be capable of operating in severe dust environments with no detrimental effects on performance. This unit shall be tested by operating the complete unit for 1500 h at 5000 rpm ± 500 rpm in an enclosure where dust is available to be circulated. This test shall be performed with a minimum of 80% of the rated alternator output. The alternator inlet air temperature shall be 93 °C ± 5 °C. Some typical dusts:

a. AC coarse dust

b. Phoenix dust

c. Fly Ash/Portland Cement dust

Specific requirements for dust and density shall be established per agreement with the manufacturer and machine designer.

## 6.2 Vibration

Alternators shall be designed to withstand the vibration environment of the application. Guidelines for acceptable vibration tolerance shall be developed by the alternator manufacturer based on industry application requirements.

Guidelines may resemble the individual speed plots and total vibration envelope shown in Figure 6. These guidelines are not exact due to resonant mode shape differences between mounting bracket systems. Alternator mounting systems shall be designed to have a minimum resonance four times the normal engine firing frequencies.

Mounting bolt strength and mounting surface hardness are important in retaining initial tightness and vibration resistant performance. Mountings of types shown in Figures 4 and 5 have been effective in adjusting differences between the alternator lug and the mounting bracket dimensions, thus providing the necessary clamping without excessive strain on the alternator lug or a requirement for close tolerances on either part.

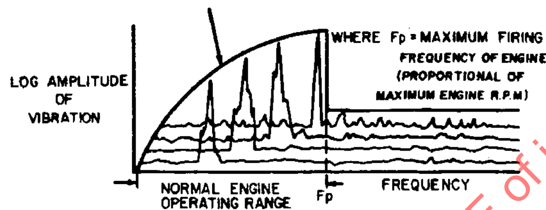



FIGURE 6 - ENGINE VIBRATION ENVELOPE

Specific requirements for vibration testing shall be established per agreement with the manufacturer and machine designer.

## 6.3 Temperature Range

Alternators shall be designed to withstand the temperature environment of the chosen application. The alternator shall operate with an air inlet temperature of -40 to 105 °C. Newer applications may see higher temperatures.

The alternator manufacturer and machine manufacturer shall jointly review the application and develop a procedure to measure the critical temperatures during actual operating conditions. Attachments that will be used on the alternator, such as debris screens, guards, etc. shall be included in these tests.

Consideration shall be given to external heat sources when designing and locating the alternator mounting. External sources of heat include engine items such as exhaust manifolds, turbochargers and mufflers.

## 6.4 Belt Loading

Belt load and pulley distance from the drive-end bearing are the most severe cause of excessive bearing loads. To attain acceptable bearing life, the machine designer shall keep within the limits provided by the alternator manufacturer. See Figure 7 for typical shaft load versus distance between bearing and load centerlines. For the alternators shown in Figure 2, which normally use a medium-duty 25 mm bearing, the curves present information based on 10 000 h B-10 life. In other combinations of shaft and bearing size, the limitation may be set by shaft fretting or shaft fatigue. The bearing B-10 life may be used for qualitative configuration comparisons, but actual bearing life must be based on application and usage experience.

To help determine the belt specifications and to help calculate the belt loading, the alternator manufacturer shall furnish curves showing the full-load horsepower and torque required to drive the alternator. For calculating loads on the drive components due to accelerations, the moment of inertia of the rotor is required.

For avoiding one cause of shaft wear and bearing failure, the pulley hub dimensions shall be consistent with shaft dimensional requirements according to Figures 1, 2, and 3. The hub shall have a free fit over the shaft so that all of the nut torque will be available for providing clamping force against bearing inner race.

Consideration shall be given to requirements specific to various drive belt systems, e.g.: “V” belts, poly “V” belts.