



SURFACE VEHICLE RECOMMENDED PRACTICE

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Electric Speedometer Specification - On Road

RATIONALE

This document covers technology and products which are mature and are either not likely to change in the foreseeable future or are no longer applicable. The development of a new standard is underway.

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1. **Scope**—This SAE Recommended Practice covers electric speedometer systems for general on-road (passenger car, multi-purpose passenger vehicle, truck, and bus) applications.

1.1 **Purpose**—To recommend design practices and test procedures for electric speedometers used in an on-road vehicle environment using the methods of determining wheel revolutions per unit of distance specified in SAE J678,¹ paragraph 2.1, and SAE J966.

2. References

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

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

SAE J678—Speedometers and Tachometers—Automotive

SAE J862 JUN81—Factors Affecting Accuracy of Mechanically Driven Automotive Speedometer-Odometers

SAE J966 AUG66—Test Procedure for Measuring Passenger Car Tire Revolutions per Mile

2.1.2 ASTM DOCUMENT—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 117—Method of Salt (Fog) Spray

2.1.3 FEDERAL SPECIFICATION—Available from the Superintendent of Documents, U. S. Government Printing Office, Mail Stop: SSOP, Washington, DC 20402-9320.

FMVSS 127

1. When reference is made to existing SAE specifications, the latest revision shall apply.

3. **Electric Speedometer System**—A typical electric speedometer system consists of an indicating unit and sender unit with inter-connecting wiring. The indicating unit is made up of a speed indicator and distance indicator (odometer). In practice, the speed indicator is very similar to a conventional electric tachometer where the indication is proportional to the frequency of the input pulses. The distance indicator may utilize a counter such as described in SAE J862, paragraph 2, and may be driven by a stepping motor through a system of reduction gearing or by a solenoid. The stepping motor or solenoid in turn is driven by voltage pulses generated by an amplifier/divider circuit or from a switch in the sender. The divider circuit serves to reduce the frequency of the input pulses from the sender that are applied to the stepping motor or solenoid. The sender unit in most applications will be one of the following types: permanent magnet generator, magnetic switch, or magnetic sensor. Generally, they are either transmission or wheel mounted.
4. **Factors Affecting Odometer System Accuracy**
- 4.1 **General**—The overall accuracy of an electric speedometer distance indicator is subject to the same inaccuracies as those described in SAE J862. While the average effect shown in Figure 1 of SAE J862 may not be directly applicable to trucks, the effect of being either over or under is the same.
- 4.2 **Transmission Driven Senders**—Referring to Figure 1 of SAE J862, the factor "Take-Off Pinion Design Limits" is applicable to transmission driven senders only. Since the number of revolutions per unit distance for transmission driven senders is generally fixed at 1000 rpm at 60 mph (96.6 km/h), the accuracy of the odometer with respect to the rotation of the sender may be closely controlled by proper gearing or electrical division within the indicating unit itself.
- 4.3 **Wheel Mounted Senders**—Corrections for variations in rolling radius may be made by proper selection of the reduction gearing between the stepper motor and the odometer or of the sender excitation frequency. Where precise selection of the sender excitation frequency is possible, the overall odometer accuracy can be very high. However, rounding off of the reduction gearing and/or electrical division in the indicating unit can produce the same type of error that is obtained by rounding off any fractional number of teeth on the speedometer drive gear in the transmission.
5. **Distance Indication (Allowable System Variation)**
- 5.1 **Overall Design Variation**—The overall odometer accuracy shall be within -4% to $+4\%$ for each actual unit of distance of travel over the operating range of the instrument. The design limits should not, however, be construed as absolute under all operating conditions. Factors which cause variations from nominal wheel revolutions under operating conditions are covered in SAE J862. It is recommended that SAE J862 be studied to determine probable effects under service conditions.
- 5.1.1 **ODOMETER INPUT**—Inaccuracies contributed by the odometer and associated circuitry will be negligible with proper selection of the number of pulses per mile (kilometer) supplied to the unit. The actual number of sender pulses per mile (kilometer) can be negotiated between the user and the manufacturer.
- 5.2 **Operating Range**—The odometer shall meet the requirements of paragraphs 6.1 and 9.1.2 at any operating speed above 5 mph (8.05 km/h).
6. **Distance Indication (Allowable Instrument Variation)**
- 6.1 With nominal input frequency applied, the odometer shall indicate calculated mileage within $\pm 0.3\%$.
- 6.2 For vehicles under 16 000 lb GVW, Federal Motor Vehicle Safety Standard 127 imposes certain requirements on the odometer and should be examined for the latest information.

7. Factors Affecting Speed Indication

- 7.1 Transmission Driven**—The overall accuracy of speed indication is affected by the same errors as distance indication since the same sender drives both the odometer and speed indicator.
- 7.2 Wheel Driven**—The speed indicator is calibrated for a nominal sender excitation frequency, therefore, the overall accuracy of speed indication is determined by the speed indicator calibration limits.
- 7.3 All Types**—Speed indication may be affected by changes in ambient temperature and voltage.

8. Speed Indication (Allowable Instrument and Sender Variation)—The speed indicating unit shall be within the limits shown in Table 1 or Table 2 (consult speedometer vendor to determine proper table) when the sender is driven at the specified frequency at a temperature of 75 ± 5 °F (24 ± 3 °C) with nominal voltage applied. When analog displays are used, the spacing of the graduations on the speedometer dial may be non-linear to compensate for non-linearity in the system. It should be noted that variations in speedometer reading on the road may lie outside the limits of Table 1 due to the factors described in Figure 1 of SAE J862. All calibration of speedometers during manufacture shall be made with the instrument in approximately the same angular position that it will have when mounted in the vehicle. See Environmental Conditions for allowable variation within the instrument due to changes in ambient temperatures and voltage.

9. Effects Of Environmental Conditions

9.1 Temperature (Allowable System Variation)

- 9.1.1 SPEED INDICATION**—With nominal voltage applied, the speed indication shall not vary more than $\pm 2\%$ of full scale from the reading determined in paragraph 8 while the indicating unit is operating over the range of +20 to +130 °F (−7 to +54 °C) and the sender is operating over the range of −40 to +280 °F (−40 to +138 °C). No permanent damage shall result from operating the indicating unit in a range of −40 to +180 °F (−40 to +82 °C). Internal lighting, if any, shall not be operating during this test.
- 9.1.2 DISTANCE INDICATION**—With nominal voltage applied, the distance indication shall not vary more than $\pm 0.3\%$ from a reading obtained at 75 ± 5 °F (24 ± 3 °C) while the instrument is operating over the range of +20 to +130 °F (−7 to +54 °C) and the sender is operating over the range of −40 to +280 °F (−40 to +138 °C). No permanent damage shall result from operating the indicating unit in a range of −40 to +180 °F (−40 to +82 °C). Internal lighting, if any, shall not be operating during this test.

**TABLE 1—SPEED INDICATION LIMITS FOR SPEEDOMETER FULL SCALE = 85 MPH
(136.79 KM/H) BIASED**

Actual Speed	mph	20	40	55
Indicated Speed	mph	18.9 – 22.4	39.5 – 43.0	55 – 58.4
Actual Speed	km/h	30	70	90
Indicated Speed	km/h	28.1 – 33.8	69.3 – 75.0	90 – 95.6

**TABLE 2—SPEED INDICATION LIMITS FOR SPEEDOMETER FULL SCALE = 85 MPH
(136.79 KM/H) NOT BIASED**

Actual Speed	mph	20	40	55
Indicated Speed	mph	18.3 – 21.7	38.3 – 41.7	53.3 – 56.7
Actual Speed	km/h	30	70	90
Indicated Speed	km/h	27.2 – 32.8	67.2 – 72.8	87.2 – 92.8

NOTE—The speedometer accuracies are a percentage of full scale. If for example a 60 mph full scale is used, the speedometer accuracy will be ± 1.2 mph. The total speedometer tolerance may be added to the actual speed to obtain the limits, as in Table 1, or may be split and added to and subtracted from the actual speed to obtain the limits, as in Table 2. Consult speedometer manufacturer to determine which method is used.

9.2 Temperature Extremes (Sender Only)—It will be necessary to evaluate the specific application to specify the allowable temperature extremes.

9.3 Storage (Indicating Unit Only)—A 4 h exposure of the indicating unit to a temperature of -40 to $+185$ °F (-40 to $+85$ °C) shall result in no more than $\pm 1\%$ of full scale permanent calibration change from the reading determined in paragraph 8. The rate of temperature change during this test shall not exceed 3.6 °F (2 °C) per minute.

9.4 Voltage Variation (Indicating Unit)

9.4.1 SPEED INDICATION—The indication shall not change more than $\pm 1\%$ of full scale indication from the reading determined in paragraph 8 within the following voltage ranges:

12 Volt System	24 Volt System
12 to 16 VDC	24 to 32 VDC

Twelve and 24 V indicating units shall not change more than $\pm 3\%$ of full scale indication from the reading obtained in paragraph 8 at 11 and 22 V respectively.

9.4.2 DISTANCE INDICATION—At 75 ± 5 °F (24 ± 3 °C) the distance indication shall not vary more than $\pm 0.3\%$ when operating within the voltage ranges given in paragraph 9.4.1.

9.5 Abnormal Voltage Conditions

9.5.1 TRANSIENT VOLTAGE PROTECTION—The indicating unit shall be capable of withstanding supply voltage transients without permanent damage and shall remain within the calibration specification of paragraphs 6.1 and 8 at the conclusion of this test.

The instrument shall be connected and operated for a total of 1 h with a means provided to impress upon the nominal battery voltage a repetitive rectangular voltage pulse of plus and minus six times nominal battery voltage with a duration of $300 \mu\text{s}$ and 1% duty cycle with a current of no more than 1.0 A.

For applications with transient voltages having a magnitude, duration, or duty cycle exceeding the above requirements, contact the instrument manufacturer for recommendations.

9.5.2 OVERVOLTAGE AND REVERSE POLARITY—Provisions for protection against booster starts with double battery voltage and/or reversed polarity must be negotiated between the user and the manufacturer.

9.6 Moisture Resistance

- 9.6.1 HUMIDITY (INDICATING UNIT)—Indicating unit shall withstand exposure to 95% relative humidity at 100 °F (38 °C) for 48 h.
- 9.6.2 SALT SPRAY (SENDER UNIT)—Sender units shall be corrosion resistant and shall withstand a salt spray (fog) test of 48 h duration with 5% salt solution (Reference ASTM B117-73).
- 9.6.3 PERFORMANCE DEGRADATION—Allowable degradation during humidity and salt spray tests (paragraphs 9.6.1 and 9.6.2) is negotiable between the user and the manufacturer.

9.7 Vibration Test (Indicating Unit)—The indicating unit shall be capable of withstanding without mechanical or electrical failure, 3 h of vibration, 1 h along each of the three mutually perpendicular axes. One axis is to be parallel to the indicator shaft. The vibration test shall be run at a double amplitude (peak to peak) of 0.030 in (0.76 mm) with the frequency varying from 10–30–10 Hz at intervals of 1 min. After completion of test, the calibration shall remain within tolerances as specified in paragraphs 8 and 6.1.

9.8 Vibration Test (Sender Only)

- 9.8.1 TRANSMISSION MOUNTED—The sender shall be capable of withstanding 6 h of vibration without mechanical or electrical failure, 2 h along each of the three mutually perpendicular axes. One axis is to be perpendicular to the mounting plane. The vibration test shall be run at a double amplitude (peak to peak) of 0.020 in (0.51 mm) with the frequency varying from 10–120–10 Hz at intervals of 1 min.
- 9.8.2 WHEEL MOUNTED SENDER—The sender shall be capable of withstanding 6 h of vibration without mechanical or electrical failure, 2 h along each of the three mutually perpendicular axes. One axis is to be perpendicular to the mounting plane. The vibration shall be run at a double amplitude (peak to peak) of 0.040 in (1.02 mm) with frequency varying from 10–120–10 Hz at intervals of 1 min.

9.9 Shock Test (Indicating Unit Only)—The indicating unit shall be capable of withstanding without mechanical or electrical failure the following series of shocks and still maintain the calibration tolerances specified in paragraphs 8 and 6.1. The indicating unit shall be subjected to one shock in each direction along each of three mutually perpendicular axes. One axis is to be parallel to the indicator shaft. Each shock shall have an amplitude of 23–27 g, half sine of 9–13 milliseconds duration.

9.10 Shock Test (All Senders)—The sender shall be capable of withstanding, without mechanical or electrical failure, six shocks of 44–55 g, half sine of 9–13 milliseconds duration in each direction along each of three mutually perpendicular axes. One axis is to be perpendicular to the mounting plane.

10. Design Detail Recommendations (Indicating Unit Only)

- 10.1 When analog displays are used, the display shall be accomplished by a pointer or other indicator traversing in a clockwise or left to right direction as applicable to register increasing speed over a suitable scale on the indicating unit dial. Consult FMVSS 127 for any requirements concerning dial specifications.
- 10.2 Graduations shall be designed for the best practical legibility and accuracy of reading.
- 10.3 Unless otherwise specified, pointers and dial printing shall be white, dial background shall be low gloss black, and visible portions of the indicating unit should exhibit low reflectivity. The distance indicator shall have white numerals on a low gloss black background except for the tenths indicator which shall have black numerals on a white background.
- 10.4 The indicating unit case shall be provided with studs for mounting by suitable U-clamps or similar means.