Speedometer and Odometer Overview

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Speedometer / Odometer Overview

- Between 2012 and 2016, various litigation matters in the USA brought attention to the long-standing SAE odometer/speedometer tolerances (typically +/- 4% in the accepted standards and recommended practices – or an 8.0% range).

- These were older documents, in which the criteria were established when more “flexible” bias-ply tires and mechanical systems were dominant. (More Variation)

Speedometer / Odometer Documents Overview

SAE J678 – Speedometers and Tachometers – Automotive (DEC1988);

SAE J862 – Factors Affecting Accuracy of Mechanically Driven Automotive Speedometer and Odometers (JAN1989);

SAE J1059 – Speedometer Test Procedure (JUN1984);

SAE J1226 – Electric Speedometer Specification on Road (FEB1983);

FMVSS Standard No. 127 – Speedometers and Odometers (Revoked in 1982);

European Economic Commission 75/443/EEC, 1975 (including the 1997 amendment);

Australian Design Rule 18/01 & 18/02, 1989 (including the 1995, 1998, and 2003 amendments);

Speedometer / Odometer Documents Overview

Bosch Automotive Handbook, 2nd Edition (1986) specifies an accuracy of ±4.0% of actual distance traveled.

NIST Handbook 44 specifies an accuracy of ± 4.0% of actual distance traveled during a two-mile test.

Australian Design Rule 18/02 specifies and accuracy of ± 4.0% of actual distance traveled over the odometer display range of 99,999 km.

International Organization of Legal Metrology: OIML R 55 – Speedometers, Mechanical Odometers and Chronotachographs for Motor Vehicles – Metrological Regulations (1981) specifies an accuracy of ± 2.0% of actual distance traveled. Note: Section 5.3 of OIML R 55 states that the maximum permissible errors (for accuracy) will be set by national regulations.

Japan Article 46

United Nations ECE R 39

Speedometer / Odometer Documents Overview

SAE J678 Reaffirmed DEC88

3.4 Speed Indication

3.4.1 ALLOWABLE VARIATION WITHIN THE INSTRUMENT—**Two philosophies exist** in calibrating the instrument for overall vehicle system accuracy.

a. Calibrate the **speedometer** at the center of the graduations so that overall vehicle system accuracy will be within a specified amount, as established by the vehicle manufacturer. The intent is to have an instrument with no system bias. **Generally ±4.0 mph (±6.4 km/h)** is an acceptable limit for the vehicle system.

b. Bias the **speedometer** calibration high so that overall vehicle system calibration will be higher than true vehicle speed.
Generally +6.0, -0.0 mph (+9.6, -0.0 km/h) is an acceptable limit for the vehicle
system.

Speedometer / Odometer Documents Overview

there shall be the following relationship between the speed indicated on the dial of the speedometer (V_1) and the true speed (V_2):

$$0 \leq V_1 - V_2 \leq \frac{V_2}{10} + 4\,\mathrm{km/h}$$ (EU, Australia)

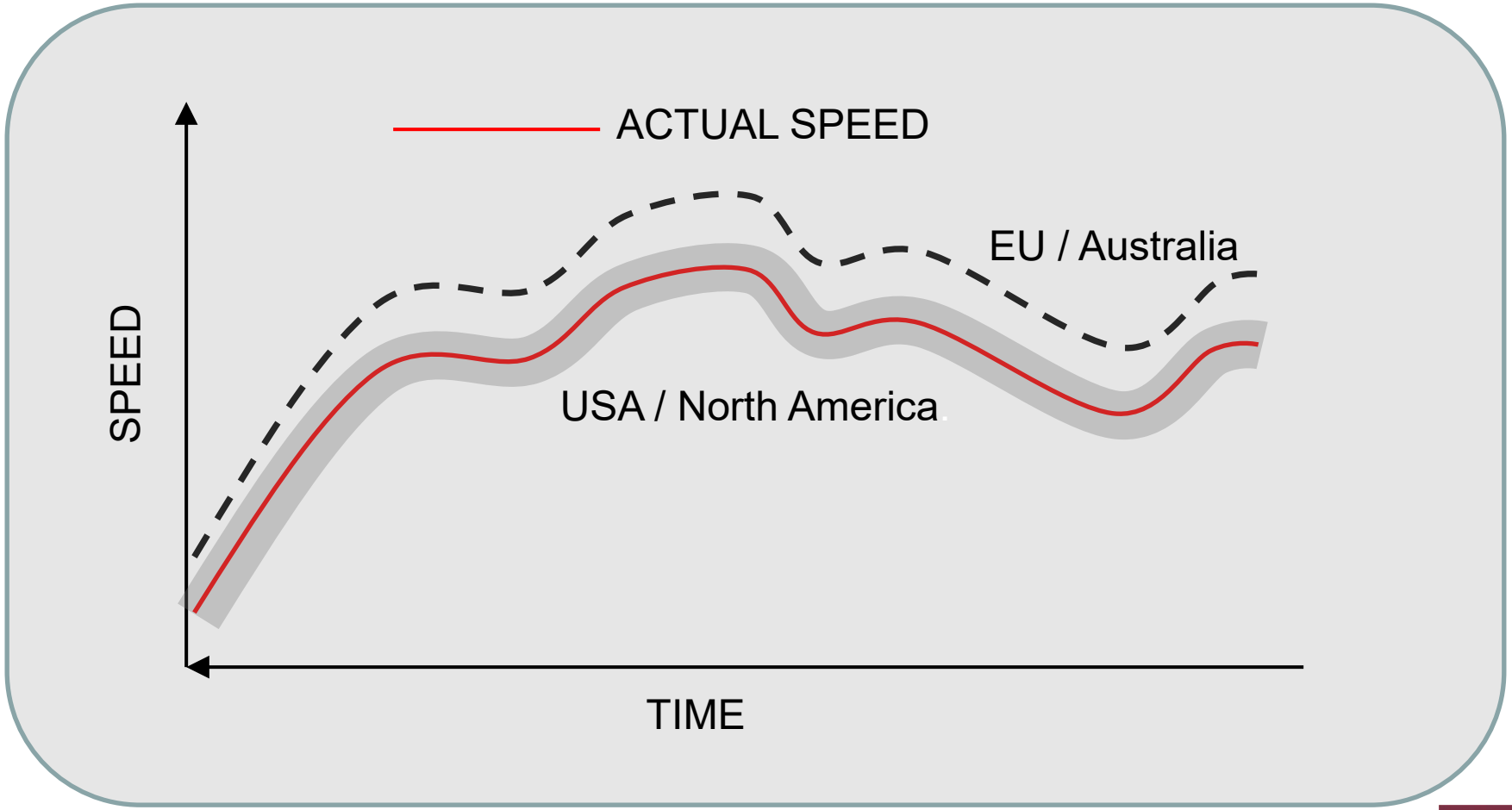
OR

$V1 = V2 \pm 4mph$

(USA / North America)

$V1 = V2 \pm 4\%$

SAE Documents Overview



Speedometer / Odometer Overview

- If a vehicle odometer over registered +3.1% for a three-year / 36,000 mile lease, and the driver returned the vehicle with 37,000 miles on the odometer (when the actual number of miles driven was slightly less than 36,000), it added a cost penalty (typically $0.25 per mile) of ~$250 penalty to the lease customer – even though the odometer performance did not violate existing criteria.
- SAE Committee J2976 was tasked with updating the accepted tolerances.

Speedometer / Odometer Overview

- Extensive testing related to the aforementioned litigation regarding over-registering odometer mileage in lease vehicles did not go unnoticed.
- For example, a handheld GPS distance device, even in 2012, was accurate to within +/- 0.3%. Thus, it was relatively easy to drive a few miles with a vehicle's trip computer set to zero at the start of the drive, and then compare it to the GPS device reading at the end of the drive. Detecting odometer over-registering or under-registering mileage was easy.

Speedometer / Odometer Overview

- Testing by various parties determined that variations in dynamic rolling radius (to which the odometer and speedometer reading/calibrations are directly proportional) were mainly affected by:
  - → Tire tread wear/reduction (+0.5% to +1.0%)
  - → Tire under/over-inflation (+/- 1.0%)
  - → Variation in tire manufacturers (+/- 0.5%)
- The SAE J2976 Working Group included members from OEMs, suppliers, the tire Industry, and other industry experts.

Speedometer / Odometer Overview

- It was known that steel-belted tires had a tighter dynamic rolling radius tolerance than bias-ply tires.
- The J2976 committee eventually agreed that a +/- 2.5% tolerance was an acceptable odometer tolerance (5.0% range).
- The speedometer also had a 5% range but is biased (for safety purposes) to -1.0% to +4%.

Speedometer / Odometer – SAE J2976

- For speed and distance purposes, tires are generally rated by dynamic rolling radius R_D when mounted on an appropriate rim and inflated to the tire manufacturer's recommended pressure.

- In the USA, there are no legal requirements except those established by (civil) legal precedent, which have turned out to be SAE J2976 requirements.

Speedometer / Odometer – SAE J2976

SAE INTERNATIONAL

SURFACE VEHICLE RECOMMENDED PRACTICE	J2976™	MAY2022
	Issued 2016-02 Reaffirmed 2022-05 Superseding J2976 FEB2016	
Speedometer and Odometer Systems for On-Highway Vehicles		

RATIONALE

SAE J2976 has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This recommended practice is intended to provide industry technical personnel with an overview of vehicle speedometer system accuracy and offset requirements and odometer system accuracy requirements. Speedometer and odometer systems covered by this document are integrated into a vehicle's electrical and electronics system, assembled directly into the vehicle by the OEM, and use rotational data from at least one vehicle wheel that is appropriately converted into longitudinal vehicle speed and distance traveled information. This standard is limited to radial ply tires on new (as manufactured) cars, light trucks, and medium duty trucks. Other methods for measuring vehicle speed and distance traveled may be used provided they meet the performance recommendations herein. Any local market regulatory requirements must be met and shall supersede this document. Service parts are beyond the scope of this recommended practice.

Odometer: +/- 2.5% (Centered)

Speedometer: -1.0% to +4.0% (Biased High)

Speedometer / Odometer - Typical Calculation

- If you are putting the tires on a Ferrari, you might want to use the 55 mph R_D value, whereas, if you are selling a Buick, you might want to use the average of the 20 mph and 40 mph R_D values.

- Typical values for an automotive tire might be:
  - → 13.3 inches (33.8 cm) at 55 mph (88.5 km/hr)
  - → 13.2 inches (33.5 cm) at 40 mph (64.4 km/hr)
  - → 13.0 inches (33.0 cm) at 20 mph (32.2 km/hr)

Speedometer / Odometer - Typical Calculation

- Let's use the Ferrari R_D = 33.8 cm, which translates to 2 x π x R_D = 2.12 meters traveled per tire revolution.

- To travel 1.0 km at 88.5 km/hr, the wheel has to experience 1000 ÷ 2.12 = <u>471.7 revolutions</u>.

Speedometer / Odometer - Typical Calculation

- At, say, 45 km/hr, the tire will rotate at a rate of **(471.7 rev/km) x (45 km/hr) ÷ (3600 sec/hr) = 5.9 rev/sec**
- 5.9 rev/sec x 2.12 m/rev = 12.5 m/s = 45 km/hr
- Different OEMs use slightly different methods to calculate speed and distance, but most are based on wheel speed data and R_D.
- The speedometer/odometer algorithm uses tire R_D calibration data combined with a counter (total revolutions) and a timer (revolutions per second), as the SAE J2976 Block Diagram shows:

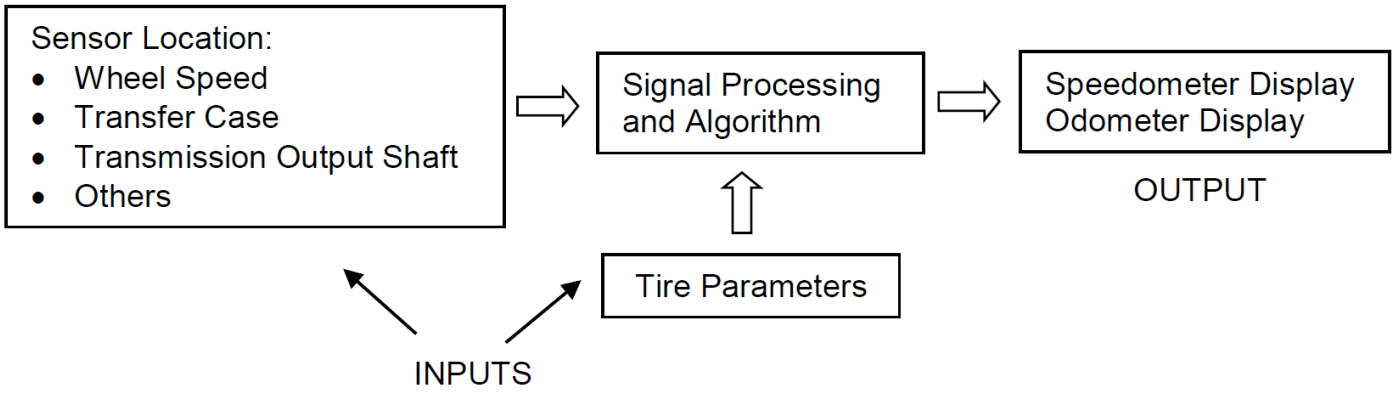
Speedometer / Odometer - SAE J2976

3. VEHICLE SPEEDOMETER AND ODOMETER SYSTEM

3.1 Types of Speedometer and Odometer Systems

Most current speedometer and odometer systems use sensor data based on tire rotation. This parameter is related to distance and time, and is converted into vehicle speed.

3.2 Tire Rotation Sensor Based System – Block Diagram



Passenger car tire parameters shall be measured using the procedure outlined in SAE J966. Truck tire parameters shall be measured using the procedure outlined in SAE J1025.

Odometer: +/- 2.5% (Centered)

Speedometer: -1.0% to +4.0%

QUESTIONS / COMMENTS