



Designation: F457 – 04 (Reapproved 2017)

Standard Test Method for Speed and Distance Calibration of Fifth Wheel Equipped With Either Analog or Digital Instrumentation¹

This standard is issued under the fixed designation F457; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of vehicle speed and cumulative distance traveled using a device termed a fifth wheel and using appropriate associated instrumentation.

1.2 This test method also describes the calibration technique applicable to digital or analog speed and distance measurement systems employing a fifth wheel.

1.3 The values stated in SI (millimetre-kilogram) units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see Section 7.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

F538 Terminology Relating to the Characteristics and Performance of Tires

F1082 Practice for Tires—Determining Precision for Test Method Standards (Withdrawn 2005)³

3. Terminology

3.1 Refer to Terminology **F538**.

¹ This test method is under the jurisdiction of ASTM Committee F09 on Tires and is the direct responsibility of Subcommittee F09.10 on Equipment, Facilities and Calibration.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

4. Summary of Test Method

4.1 Vehicle speed and distance determinations are made by use of a fifth wheel, signal transducer(s), and compatible display devices.

4.2 The fifth wheel assembly and signal transducer(s) are attached to the vehicle or the test trailer so that the fifth wheel remains in contact with the normal roadway surface while the equipment is in motion. The rotation of this wheel is detected in a suitable manner and is translated into measurements of vehicle speed and distance with auxiliary equipment.

4.3 The speed is to be communicated to the vehicle operator at all times, and should be visible without undue distraction or a requirement for physical movement on the part of the operator.

4.4 Fifth wheel calibration is performed by operating the device at a fixed speed over a known distance and comparing the speed and distance readout to a known speed and distance.

5. Significance and Use

5.1 This test method may be used for calibration of speed and distance measurement systems used on tire test vehicles and tire test trailers, or any land-based vehicle that contacts the road and that uses a trailing-wheel system for measurement of speed and distance. This test method applies only to hard, dry, smooth surfaces and is not accurate for highly curved vehicle paths. This test method does not encompass optical types of devices.

6. Apparatus

6.1 *Fifth Wheel*—The fifth-wheel assembly shall be of sufficient mechanical integrity to withstand long periods of sustained operation with minimal maintenance. The wheel vertical pivot assembly shall be sufficient to permit directional changes without inducing lateral skidding of the fifth-wheel tire. The fifth-wheel assembly shall be equipped with a suspension capable of minimizing bounce and wheel hop, due to roadway irregularities, to the extent necessary to ensure measurement accuracy. The wheel shall be equipped with a suitable tire, preferably of a straight-ribbed design. The tires shall have a minimum (new) size of 349–37 ($16 \times 1\frac{3}{8}$). Tire and wheel shall be balanced statically each time the tire is replaced.

6.2 *Instrumentation*—Fifth-wheel systems shall be equipped with either analog or digital instrumentation for determining wheel rotation. Suitable readouts shall be provided.

6.2.1 *Analog Instrumentation:*

6.2.1.1 *Generator (tachometer)*—The generator shall be coupled to the fifth wheel to produce an electrical output proportional to the angular velocity (converted into linear velocity expressed in km/h (mph)) of the fifth wheel. The generator output shall be continuously proportional to the rotational velocity within the required tolerance. The generator output shall be biased after engineering unit conversion by an amount less than or equal to 0.5 % of the converted speed, or 0.3 km/h (0.2 mph), whichever is greater. The generator response to changes in speed shall not exceed 0.5 s throughput. Generator operation shall not be degraded by direct or condensed moisture, road film, petroleum residue, dust, salt, or other environmental contaminants and ambient temperature extremes.

6.2.1.2 *Speed Readout*—The display shall measure the generator output and display the output as kilometres per hour (miles per hour). The generator output readout shall be equipped with a low pass active filter that will reduce the ripple output of the generator to less than or equal to 1 % of the measured signal or 0.8 km/h (0.5 mph) peak to peak, whichever is greater. The maximum propagation delay of the filter/readout combination shall not exceed 0.5 s. The readout shall be biased to an amount less than or equal to 1.0 % of the true speed, 0.5 km/h (0.3 mph), whichever is greater.

6.2.1.3 *Distance Readout*—The distance measuring device shall consist of a counter actuated by the fifth wheel with an output of at least 31 counts per metre (10 counts per foot). Distance traveled is calculated by multiplying the distance per pulse by the number of pulses indicated. The count shall be restorable to zero and possess sufficient digit capacity to minimize the need for recycling the count during testing. The analog integration of an electrical generator signal to yield a distance measurement is not recommended. The distance measuring device shall have a capability of a resolution of 8 cm (3 in.).

6.2.2 *Digital Instrumentation:*

6.2.2.1 *Transducer*—The digital transducer shall produce a periodic electrical signal whose period is some integer fraction of the revolution rate of the fifth wheel, and there shall be a minimum of ten signal counts per 0.3 m (1 ft) of travel of the fifth wheel along the vehicle path. The transducer shall be capable of providing the periodic electrical signals at speeds from zero to the maximum speed necessary for the test being conducted. Transducer operation shall not be degraded by direct or condensed moisture, road film, petroleum residue, dust, salt, or other environmental contaminants and ambient temperature extremes.

6.2.2.2 *Distance Readout*—The distance display presented to the operator shall consist of a digital number representing the distance traveled. The use of analog integration is not recommended unless equipment adjustments can be maintained within the tolerances stated below, over the expected

ambient temperature range. The distance measuring device shall have a capability of a resolution of 0.076 ± 0.038 m (0.25 ± 0.125 ft).

6.2.2.3 *Speed Readout*—The speed display device shall consist of a digital number. The use of analog integration or successive approximation techniques of speed determination, or both, are not recommended unless equipment adjustments can be maintained within tolerances stated below, over the expected temperature range of the instrumentation environment. The speed readout displays shall be communicated to the vehicle operator at all times without causing undue distractions or requiring physical movement on the part of the operator. The minimum increment of the digital speed readout shall be 1 km/h, if the readout displays in km/h, or 1 mph, if the readout displays in mph.

6.3 *Tire Pressure*, to be accurate to 3 kPa (0.5 psi).

6.4 *Stopwatch* (required only for analog instrumented fifth wheel).

7. Safety Precautions

7.1 Fifth-wheel assemblies shall be inspected periodically to assure security of attachment. A safety chain is recommended to prevent loss under extreme operating conditions. Wheel assemblies should not be subjected to undue side forces, or other conditions that may either impair accuracy or present a hazard to adjacent vehicles.

8. Calibration Procedure

8.1 Since analog instrumentation measures fifth-wheel angular velocity and digital instrumentation measures angular displacement, follow different calibration procedures for each system. In either case, accomplish calibration by adjustments of electronics rather than tire pressure or other mechanical means. Adjustment of tire pressure may affect the dynamics of the fifth-wheel suspension and may disrupt optimum tire-road contact. However, small tire inflation pressure changes less than 5 psi may be used for small recalibration adjustments.

8.2 *Fifth-Wheel Preparation:*

8.2.1 Install the fifth wheel according to the manufacturer's instructions and as near as possible to the mid-track position of the vehicle.

8.2.2 Adjust the fifth-wheel tire pressure to the manufacturer's specification.

8.2.3 It is common practice that the fifth wheel be prepared for testing by running at least 8 km (5 miles) at approximately 64 km/h (40 mph) immediately before use. Normal travel in preparation for calibration fulfills this requirement.

8.3 *Analog Calibration*—The ultimate accuracy of speed measurements is determined principally by the accuracy to which the speed per volt or current calibration can be established and how constant this calibration remains over the range of speed and over time. The accuracy of the distance measurement is dependent primarily upon the accuracy to which the distance traveled per revolution of the fifth wheel can be determined. The number of fifth wheel revolutions should be determinable to ± 0.1 revolution in 0.8-km (0.5-mile) distance, measured using a device whose calibration is traceable to the

National Institute of Standards and Technology (NIST). This calibration should be accomplished by adjustments of electronics rather than tire pressure or other mechanical means. Adjustment of tire pressure may affect the dynamics of the fifth wheel suspension and may disrupt optimum tire-road contact. However, tire pressure changes of less than 34 kPa (5 psi) may be used for recalibration. Initial and final tire pressure should be recorded for future reference and calibration verification.

8.3.1 *Speed Calibration:*

8.3.1.1 Prepare the fifth wheel in accordance with 8.2.

8.3.1.2 Adjust the speed indicator and graphic recorder meter, if necessary, to zero while the vehicle is stationary.

8.3.1.3 For analog systems, drive the test vehicle at a constant speed, ± 0.8 km/h (0.5 mph), along a straight test course of at least 0.8 km (0.5 miles) measured using a device whose calibration is traceable to the National Institute of Standards and Technology (NIST), at the speed(s) at which tire tests are to be conducted. Measure the time(s) required to traverse this distance with a stopwatch, record fifth wheel output, and compute vehicle speed(s). For digital systems, drive the test vehicle in accordance with 8.4.1 through a trap of calibrated distance of at least 0.8 km (0.5 miles) measured using a device whose calibration is traceable to the National Institute of Standards and Technology (NIST). Record the number of counts for the distance and repeat four times. Average the runs and compute the number of pulses per second at 1 km/h if the calibration is being performed in km/h, or 1 mph if the calibration is being performed in mph. Using a frequency generator monitored by a frequency counter, input a frequency equivalent to the highest speed expected during testing. Adjust the output of the readout or signal conditioner for engineering conversion to an easily readable display. Repeat this for several (at least five) different frequencies through the range expected during the test. Record the results for future reference and calibration verification.

8.3.1.4 If the speed readout and recorder are not equal to the computed speed to within ± 0.5 km/h (0.3 mph), adjust either the recorder gain or meter gain, or both, to achieve correspondence. Repeat 8.3.1.3 until this requirement is met.

8.3.1.5 Following compliance with the accuracy requirement of 8.3.1.4, four additional test runs shall be made (two in each direction). Compliance with 8.3.1.4 in all four runs shall constitute a satisfactory speed calibration if the data repeats to ± 0.8 km/h (± 0.5 mph) or to 1 % of the speed to be used for the tests, whichever is greater.

8.3.2 *Distance Calibration:*

8.3.2.1 Paragraphs 8.2.1 – 8.2.3 should be followed if the speed calibration was not performed.

8.3.2.2 Position the test vehicle at one end of a test course of at least 0.8-km (0.5-mile) certified length. Record the relative position of the vehicle and course beginning marker.

8.3.2.3 After recording the fifth-wheel revolution counter reading, smoothly accelerate the test vehicle to the tire testing speed and stop smoothly at the other end of the course with the end marker in the same relative position as at the beginning of the course.

8.3.2.4 Note the fifth-wheel revolution counter reading and calculate the number of revolutions.

8.3.2.5 Calculate the distance calibration factor F as follows:

$$F = \frac{\text{Test course length}}{\text{Number of fifth wheel revolutions}}$$

8.3.2.6 Four such test runs shall be performed (two in each direction) with the final calibration factor (F) being the average of the four calculations. Unknown distances may now be measured by multiplying the calibration factor (F) by the number of fifth-wheel revolutions in the unknown distance.

8.4 *Digital Calibration*—The ultimate accuracy of digital speed and distance measurements is determined principally by the accuracy to which the distance per pulse is adjusted over a course of known length. Periodic calibration is required to compensate for such factors as tire treadwear, tire aging and growth, rolling resistance, and temperature at various speeds. This calibration should be accomplished by adjustment of electronics rather than tire pressure or other mechanical means. Adjustment of tire pressure may affect the dynamics of the fifth-wheel suspension and disrupt optimum tire-road contact conditions. However, tire inflation pressure changes may be used for small recalibration adjustments. Initial and final tire pressure should be recorded for future reference and calibration verification.

8.4.1 *Distance Calibration:*

8.4.1.1 Prepare the fifth wheel in accordance with 8.2.1 – 8.2.3.

8.4.1.2 Set the instrumentation in the distance mode (if required) and reset the display to zero.

8.4.1.3 From start to stop, the test vehicle shall traverse a test course of at least 0.8-km (0.5-mile) certified distance. The vehicle operator shall accelerate the vehicle smoothly to the tire testing speed, maintain this speed, and then decelerate smoothly at the other end of the course. The vehicle shall come to rest with the “end” marker in the same relative position as the “start” marker was at the beginning of the course.

8.4.1.4 Comparison between instrumentation display and actual course length indicates the error for which adjustments must be made. Simply obtain the quantitative error by subtracting the instrumentation display value from the known course length, or vice versa. Observe the digital distance readout and determine the distance error for the course length.

8.4.1.5 Adjust the electronic calibration controls to reconcile course length and measured distance, in accordance with the manufacturer’s instructions for calibration. The difference between actual course length and measured distance shall not exceed 0.1 % (1 m in 1 km (or 5.28 ft in 1 mile)). At least four distance determinations, two in each direction, within the specified tolerances shall constitute a satisfactory distance calibration.

8.4.2 *Speed Calibration*—Check the speed indicating instrumentation by running a speed calibration in accordance with 8.3.1.3. The speed readout should automatically be within the specifications in 6.2.2.3 when distance is calibrated according to the above procedure.

9. Precision and Bias

9.1 This precision and bias section has been prepared in accordance with Practice F1082. Refer to this practice for

terminology and background. Reproducibility, which is a measure of the usual laboratory-to-laboratory test variation or in the case of proving ground testing, test site-to-test site variation, has not been evaluated. This type of variation is in general not applicable to the use of this test method.

9.2 The precision is given in terms of the repeatability, r . This parameter is derived from the standard deviation of the measurement in question (see Practice F1082). The bias is the deviation of the measured test value from the true or reference value, established by another standardized measurement or from some recognized reference value. Bias may be positive or negative.

9.3 *Distance Measurement*—The precision and bias for distance measurement is given in Table 1. The table shows that for the three speeds listed, the bias is a minimum at 64 km/h (40 mph) and that it grows negative at lower speeds and more

TABLE 1 Precision and Bias for Distance Measurement

	Speed or Velocity, km/h (mph)		
	32 (20)	64 (40)	96 (60)
Average bias, m (ft)	-0.70 (-2.3)	0.40 (1.3)	1.53 (5.0)
Standard deviation, m (ft)	0.15 (0.49)	0.29 (0.94)	0.49 (1.6)
Repeatability, r , m (ft)	0.43 (1.4)	0.82 (2.7)	1.37 (4.5)

positive at higher speeds. The standard deviation and the repeatability increase as speed increases.

9.4 *Speed or Velocity Measurement:*

9.4.1 *Bias*—The bias of speed measurement has been estimated to be equal to or less than 1.6 km/h (1 mph) at a speed of 64 km/h (40 mph).

9.4.2 *Repeatability*—The repeatability of speed measurement has been estimated to be 3.2 km/h (2 mph).

10. Keywords

10.1 analog; calibration; digital; distance; fifth wheel; speed

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